
UPPER PALEOCENE TO LOWER EOCENE ("MEGANOS STAGE") MARINE MEGAFOSSILS IN THE UPPERMOST SANTA SUSANA FORMATION, SIMI VALLEY, SOUTHERN CALIFORNIA

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ABSTRACT. Uppermost Paleocene to lowermost Eocene ("Meganos Stage") marine rocks are rare on the Pacific coast of North America, and the upper 100 m of the Santa Susana Formation in Simi Valley represents the only known "Meganos Stage" rocks in southern California. This report concerns the first detailed study of mega-invertebrate fossils in this part of the formation. The fossils are in thin lenses that formed as storm-lag accumulations in a relatively shallow, offshore environment. Thirty localities yielded a total of 38 megafossil taxa identifiable to species or subspecies. These include one isidid octocoral, one solitary coral, two colonial corals, 17 gastropods, 14 bivalves, two crabs, and one spatangoid echinoid. A new species of solitary coral, *?Antillophyllia californica* new species, is described and named. A possible new species of the colonial coral *Astrocoenia* is described. *Turritella andersoni susanae* is locally abundant and one of the most diagnostic species of the "Meganos Stage" in the Simi Valley area.

Most of the studied megafauna is known from elsewhere in Pacific coast Eocene strata, primarily in California. The molluscan-stage ranges of approximately one third of the studied mega-invertebrates are extended downward to the "Meganos Stage," based on their presence in the upper 100 m of the Santa Susana Formation. The molluscan-stage ranges of the gastropod *Ringicula* (R.) *pinguis*, the bivalve *Saulella undulifera*, and the crab *Cyclocorystes aldersoni* are extended upward from the Paleocene "Martinez Stage" to the "Meganos Stage." In addition, a few of the mega-invertebrates have their geographic ranges extended. The isidid octocoral *?Mopsea* sp., aff. *M. costata* is the first record of an isidid from Paleogene rocks on the Pacific coast of North America. The studied megafauna is indicative of warm-water conditions, and some of the taxa are conspecific with or closely allied to Old World Tethyan mollusks.

INTRODUCTION

Since the early 1900s, paleontologists have collected marine megafossils from the Santa Susana Formation in the Simi Valley area (Fig. 1), Ventura County, southern California. These fossils, which are predominantly mollusks, have been studied by Waring (1917), Nelson (1925), Fantozzi (1955), and Zinsmeister (1983a, 1983b), but their studies dealt only with "Martinez Stage" rocks of late Paleocene age in the lower part of the formation on the south side of Simi Valley. Although various workers have found a few mollusks in the upper 100 m of the Santa Susana Formation, to date there has not been a comprehensive study of these fossils. Poor exposures, absence of fossils at many locales, and generally poor preservation have discouraged such study, and prior to this study no one had ever "walked out" the stratigraphic interval throughout the Simi Valley area. In addition, outcrops of the upper 100 m of the Santa Susana Formation have the same color and general appearance of essen-

tially unfossiliferous outcrops stratigraphically lower in the Santa Susana Formation. Many previous workers seemed to have assumed that the upper 100 m are not particularly fossiliferous. Locally, however, megafossils are abundant there, and their preservation can be good. The purpose of this present study is to document the taxonomic composition of the megafossil content in these upper 100 m. This information will help greatly in refining the molluscan stage ranges of these taxa because the upper 100 m of this formation correlate to the "Meganos Stage" of latest Paleocene to earliest Eocene age. Rocks deposited on the Pacific coast of North America during this time interval are relatively rare, and those in the study area represent the only known "Meganos Stage" rocks in southern California.

The molluscan stage terminology used in this report includes the upper Paleocene "Martinez Stage," the uppermost Paleocene to lowermost Eocene "Meganos Stage," the middle lower "Capay Stage," the upper lower to lower middle "Domenigine Stage," the lower middle "Transition Stage," and the middle middle Eocene to upper Eocene "Tejon Stage." The stage names are in quotes because they are informal terms and in essence equivalent to formation names. Clark and Vokes (1936) gave

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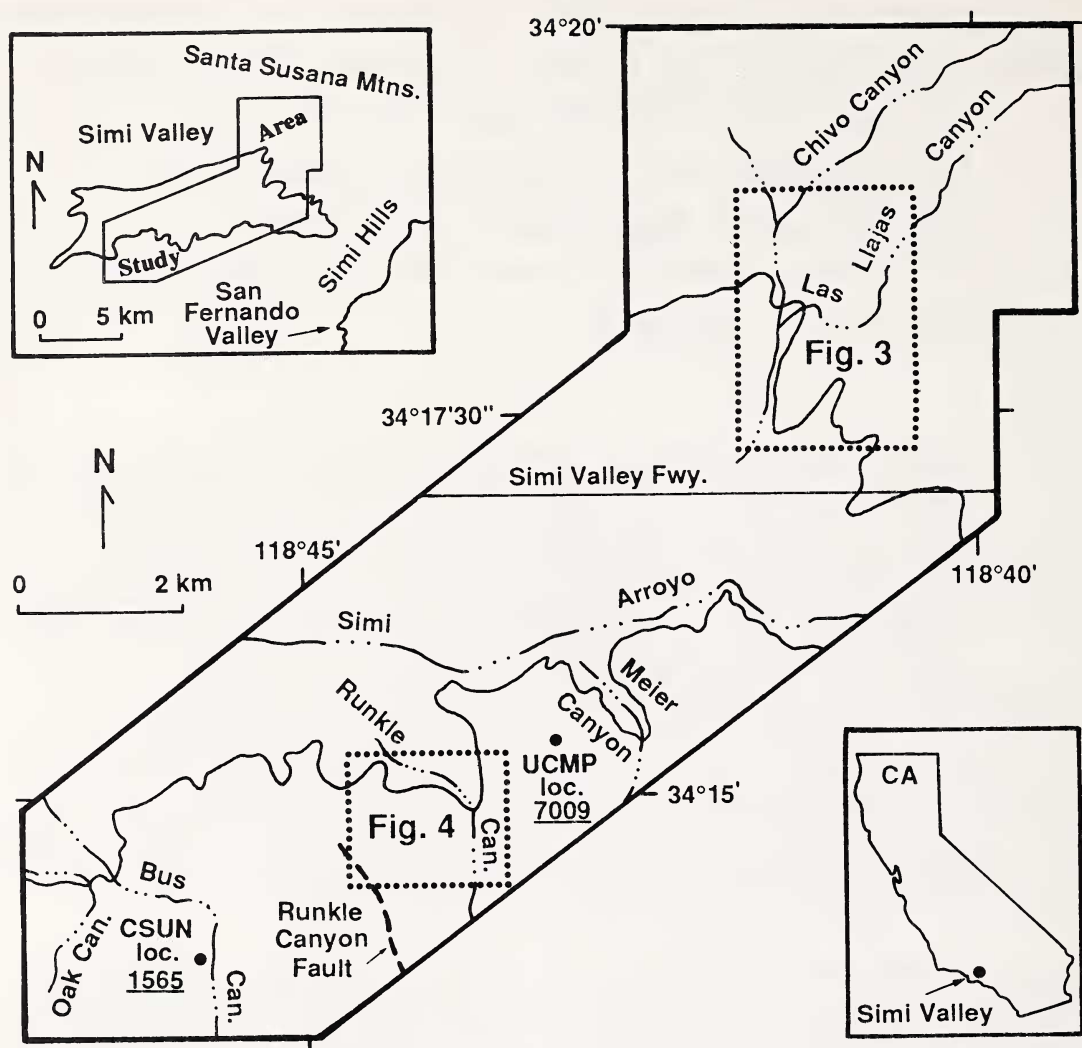


Figure 1. Index map of Simi Valley, also showing areas used for Figures 3 and 4.

a historical overview of these stage names. Givens (1974) modified the use of the “Capay Stage,” and it is in this modified sense that the “Capay Stage” is used here. Saul (1983) and Squires (1984, 1987, 1988a) regarded the modified “Capay Stage” of Givens (1974) as middle lower Eocene.

STRATIGRAPHY

The upper 100 m of the approximately 1000-m-thick Santa Susana Formation in the Simi Valley area consists mostly of gray, very fine-grained sandstone, with some gray muddy to sandy siltstone. Locally, there are concentrations of fossil-shell hash, and rocks surrounding these localized concentrations are barren of megafossils. The lower part of the upper 100 m of the Santa Susana Formation has a gradational lithology from the underlying gray mudstone and siltstone. The Santa Su-

sana Formation is disconformably overlain by basal conglomerate of the Llajas Formation (Fig. 2), and the contact is an uneven erosion surface with as much as 1 m of relief. Thin beds of laminated sandstone alternating with thin beds of bioturbated sandstone containing vertical *Ophiomorpha* burrows are present at the top of the Santa Susana Formation at two places on the north side of the valley. One location is at CSUN locality 968, and the other location is just north of the Marr Ranch (Fig. 3) in the northeast corner of section 31, T3N, R17W, where the type section of the overlying Llajas Formation is located (see Squires, 1981:fig. 3) (Fig. 3).

Sedimentary rocks in the upper 100 m of the Santa Susana Formation are not resistant and are usually poorly exposed or covered. The best exposures are on the north side of Simi Valley, where 19 fossil-

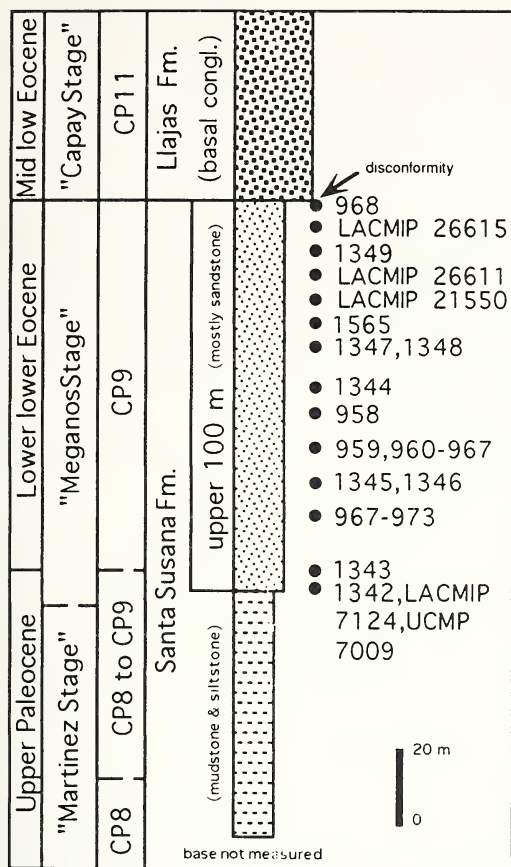


Figure 2. Stratigraphic column of the upper 100 m of the Santa Susana Formation (and of the immediately underlying and overlying strata), showing subseries, provincial molluscan stages, calcareous nannofossil biozones (CP Zones), and stratigraphic position of each of the megafossil-collecting localities. Age of the lower part of the Lajas Formation from Squires (1984).

collecting localities have been found (Fig. 3). CSUN localities 962 through 967 are approximately aligned along the same strike and form a series of localities that parallels the top of the Santa Susana Formation. CSUN localities 969 through 973 are similarly aligned. Four localities (CSUN 968, LACMIP 21550, LACMIP 26611, and LACMIP 26615) are near the top of the formation. At nearly all of the localities on the north side of Simi Valley, fossils are concentrated in lenses about 20 cm thick and several meters in lateral extent. The tops and bottoms of the lenses are indistinct. The bivalves in the lenses are almost always single valves and usually broken, and many of the associated gastropods consist of fragments. Although the fossils are mostly broken, none shows any obvious signs of abrasion. Specimens of *Turritella andersoni susanae* Merriam, 1941 are plentiful and dominate the otherwise usually meager megafauna. At CSUN local-

ity 959, there is a thin lens containing abundant *Turritella uvasana infera* Merriam, 1941 and the lens is traceable laterally for about 6 m. This locality is now under home sites.

On the south side of Simi Valley, 11 fossil-collecting localities have been found in the upper 100 m of the Santa Susana Formation (Figs. 1, 4). An isolated locality (CSUN 1565) is in Bus Canyon, and another isolated locality (UCMP loc. 7009) is near Meier Canyon (Fig. 1); the other localities are in two groups, with six localities found mostly near the top of the Santa Susana Formation in the Runkle Canyon area and three localities just east of the Runkle Canyon fault (Fig. 4). At most of these localities on the south side of Simi Valley, the fossils are similar to those on the north side of the valley, and there are concentrations of unabraded fossil-shell hash in thin lenses whose tops and bottoms are indistinct. Abundant weathered-out specimens of the solitary coral *Antillophyllia californica* new species, abundant tips (apices) of turritellas, and commonly occurring mostly right valves of the bivalve *Pycnodonte* (*Phygraea*) sp., aff. *P. (P.) pacifica* Squires and Demetron, 1990 were found in float at CSUN locality 1343.

The relative stratigraphic position of each megafossil locality in the upper 100 m of the Santa Susana Formation, on both the north and south side of Simi Valley, is shown in Fig. 2.

DEPOSITIONAL ENVIRONMENT

Parker (1983) did the most current and detailed study of the depositional environment of the Santa Susana Formation and reported that the vertical sequence of the Simi Conglomerate, Las Virgenes Sandstone, and Santa Susana Formation represents a transition from nonmarine to deep-marine facies. The distribution of these facies is, in part, defined by the Runkle Canyon-Burro Flats fault zone in the central part of the south side of Simi Valley. Parker (1983) referred to strata west of this fault zone as the "western facies," and these include, from base to top, braided river, meandering stream, near-shore, transition zone, offshore to shelf, and slope deposits. He referred to strata east of this fault zone as the "eastern facies," and these consist mostly of slope and inner-fan deposits. The fault zone juxtaposes coeval nonmarine and deep-marine rocks and accounts for the fact that nonmarine to nearshore Las Virgenes Sandstone, for example, is present only west of the fault (Fig. 5).

Parker (1983) reported that although the Santa Susana Formation was mostly deposited in deep water, the sedimentology of the upper 100 m of the formation throughout the Simi Valley area reflects uplift to shelf depths prior to deposition of the non-marine basal part of the Lajas Formation. New sedimentologic information obtained during this present study shows that the shallowing event Parker (1983) recognized produced, toward the top of the Santa Susana Formation, sediments deposited

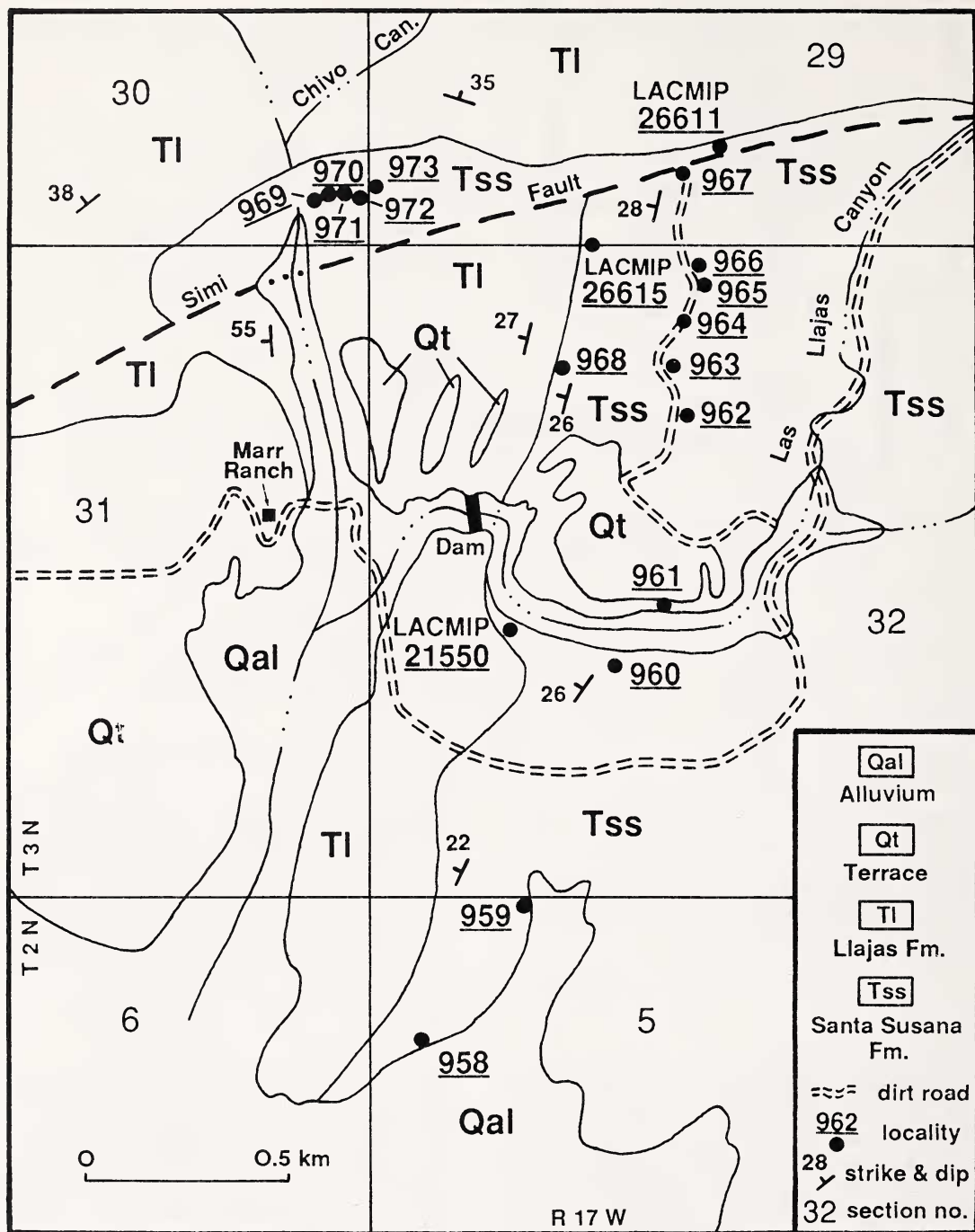


Figure 3. Geologic map showing location of megafossil localities (CSUN localities unless otherwise noted) on the north side of Simi Valley. Base map is U.S. Geological Survey, 7.5-minute, Santa Susana quadrangle, 1951 (photorevised 1969), Ventura County, southern California. Geology from Squires (1983b).

in progressively more shallow water. Beds of alternating laminated sandstone and bioturbated sandstone (e.g., at CSUN loc. 968) were found at the top of the formation, and this alternation of lithologies, which is also present in the shallowest marine

part of the overlying Lajas Formation, is characteristic of modern and ancient shoreface to upper offshore environments (Squires, 1981).

Heitman (1983), on the basis of benthic foraminiferal assemblages, also reported that the upper-

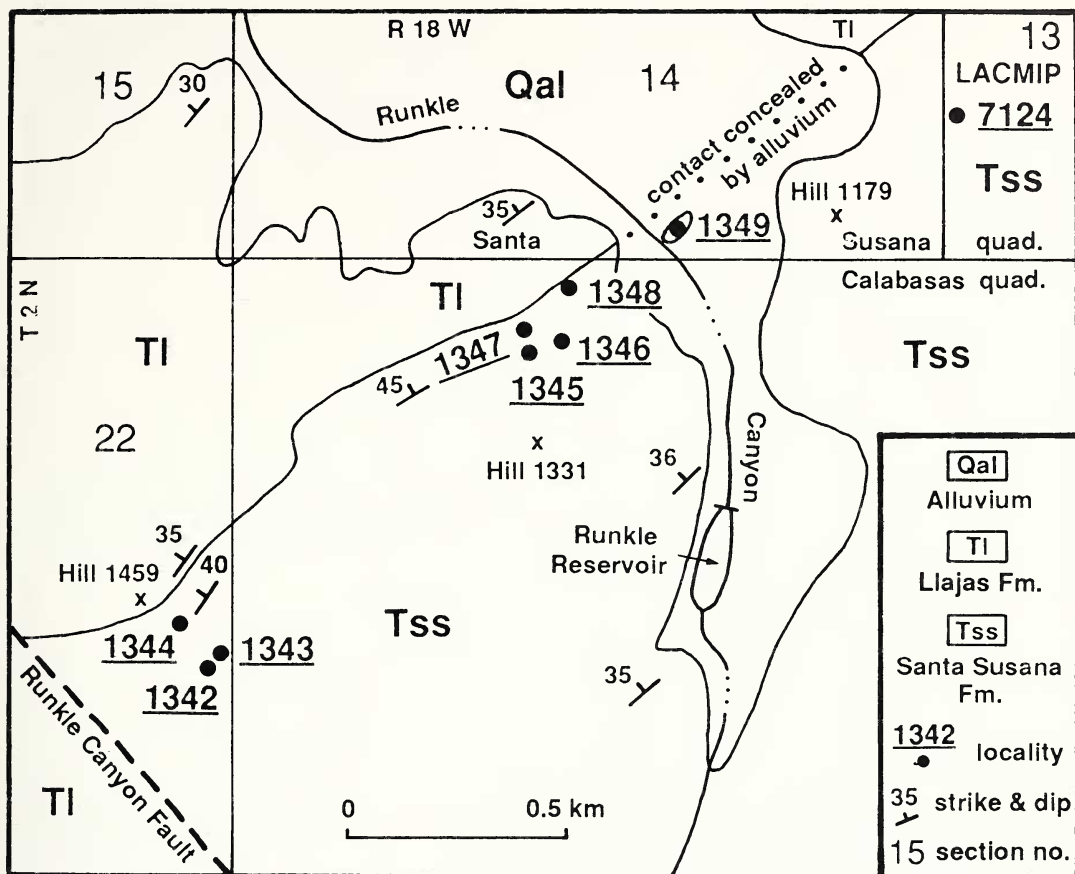


Figure 4. Geologic map showing location of megafossil localities (CSUN localities unless otherwise noted) on the south side of Simi Valley. Base maps are U.S. Geological Survey, 7.5-minute Calababas quadrangle, 1952 (photorevised 1967); and Santa Susana quadrangle, 1951 (photorevised 1969), Ventura County, southern California. Geology from Squires (1983b).

most part of the Santa Susana Formation represents a shoaling event associated with basin filling that deposited a silty sandstone just above the shelf-slope break. Filewicz and Hill (1983), on the basis of calcareous nannofossil datums and sediment-accumulation rates, reported that silty sandstones in the upper Santa Susana Formation (20 m below the base of the overlying Llajas Formation) were deposited just above the shelf-slope break.

Squires (1991a) and Saul and Squires (1997) interpreted that megafossils in the upper 100 m of the Santa Susana Formation on the north side of Simi Valley are shallow-marine forms deposited as storm-lag accumulations in a relatively shallow, off-shore environment. This more detailed present study further supports these earlier interpretations.

Squires (1990) suggested that the fossiliferous lens at CSUN locality 1342, in the upper 100 m of the formation on the south side of Simi Valley, represents a storm deposit in a middle to outer shelf environment, and that the distance of postmortem

transport of the shallow-marine mollusks was not great.

At all of the fossil localities mentioned in this present report, fossils occur as concentrations in small lenses of sandstone surrounded by siltstone usually barren of megafossils. The tops and bottoms of these lenses are indistinct, and Squires (1981) reported similar lenses in the overlying Llajas Formation, where the shallow-marine facies grades into outer shelf to slope facies. In this transitional paleoenvironment, the contacts of the fossiliferous lenses were rendered indistinct by the activities of burrowing organisms shortly after deposition of the sediments, undoubtedly just like those in the upper 100 m of the Santa Susana Formation.

It is readily apparent that the fossils in the upper 100 m of the Santa Susana Formation have undergone some postmortem transport, based on their broken condition and localized concentrations. The distance of this transport was not great based on the absence of any evidence of significant abrasion.

Waring 1917	Clark 1918	Clark 1921, Kew 1924	Nelson 1925		Clark 1926	Parker, 1983, Saul, 1983, & This Report	Mollusk "Stages"		
		W E	W	E		W	E		
Tejon	Tejon	Meganos Fm.	Domengine Fm.		Domen- gine Fm.	Llajas Fm.	"Domen- gine"		
Martinez	Meganos						Santa Susana Fm.	upper 100 m of Santa Susana Fm.	"Capay"
	Martinez	Martinez Fm.	Martinez marine member	Martinez marine member	Santa Susana Shales	Santa Susana Fm.	"Martinez"		
								Las Virgenes Sandstone	Las Virgenes Sandstone
								Simi Conglomerate	Simi Conglom.
Chico		Chico Fm	Chico			Chatsworth Fm.	Campanian		

Figure 5. Comparative concepts of lower Paleogene stratigraphic units in the Simi Valley area. The letters "W" and "E" refer to west and east of the Runkle Canyon fault (shown in Fig. 1).

In addition, the fossils are ecologically similar. Burial was rapid because there is a scarcity of epibionts. Most of the fossils represent storm-lag accumulations in a middle-to-outer shelf environment, where fine sands accumulated in close proximity to siltstone. Bioturbation must have obliterated any initially sharp contacts that would have been formed along the bottoms of the fossiliferous lenses.

CSUN locality 1343, however, is unusual because the abundant specimens of the solitary coral? *Antillophyllia californica* new species found there constitute a growth series. These corals must have lived in close proximity to where they were buried and experienced much less distance of postmortem transport than the other associated fossils.

In summary, the overall fine-grained rock type, the assemblages of benthic foraminifera, the localized concentrations of unabraded shallow-marine megafossils, and alternating rock types at the top of the formation indicate that the bulk of the upper 100 m of the Santa Susana Formation in the Simi Valley area was deposited in a relatively shallow, offshore environment (middle-to-outer shelf depths). Storm surges transported the megafossils,

but the distance of transport was not far. Beds at the top of the formation were deposited in a shallower environment (shoreface).

MEGAFAUNA

A total of 560 megafossil specimens were collected from 30 localities. Preservation ranges from poor to good, and many of the fossils are badly weathered or in hard concretions. Thirty-eight megafossil taxa were identified to genus and species/subspecies. These include one octocoral, one solitary coral, two colonial corals, 17 gastropods, 14 bivalves, two crabs, and one spatangoid echinoid. Other taxa too poorly preserved for generic identification include one solitary coral, one scaphopod, three gastropods (a naticid, a cymatiid, and a turrid), and four bivalves (a pinnid, a lucinid, a pitarinid, and a solenid). The poorly preserved solitary coral was mentioned by Durham (1943:199, pl. 32, fig. 22), who reported two specimens from UCMP locality 7000 (exact location not known). Only the exterior morphology of this coral is known. It is alate and somewhat flabelliform, but better preserved speci-

mens and studies of their interiors are needed to determine the familial or generic assignments. No new specimens were found during this present study. Durham (1943) identified the coral as *Flabellum stantoni* Durham, 1943, a name that he also gave to specimens that Vaughan (1900:67–68, pl. 4, figs. 5, 6) had misidentified as *Flabellum remondianum* Gabb (1864:207, pl. 26, fig. 199). Vaughan's specimens were probably collected from "Martinez Stage" rocks near Benicia in northern California. Durham (1943) was probably correct in giving the name *F. stantoni* to Vaughan's specimens from Benicia, but whether or not this name is appropriate for the two poorly known coral specimens from the upper part of the Santa Susana Formation is an open question. These two coral specimens are not the same as the new species of solitary coral described here.

Although early workers (Clark, 1921:table 1; 1926:114–116; Kew, 1924:25; Nelson, 1925:pl. 61, and foldout between pages 402 and 403) gave faunal lists for so-called "Meganos" age-strata in the Simi Valley area, there are serious problems in trying to use these lists because (1) detailed locality information is lacking, and (2) previously used formation names (e.g., Meganos and Domengine) are not exact equivalents of the upper 100 m of the Santa Susana Formation (Fig. 5). In addition, because these species names have only been listed, without illustration or reference to catalogued museum specimens, there is no way to verify the identifications.

Three previously named megafossil species have their type localities in the upper 100 m of the Santa Susana Formation in the Simi Valley area. They are the gastropod *Corsania* (*Januncia*) *susana* Saul and Squires, 1997 and the bivalves *Arca* (*Arca*) *filewiczii* Squires, 1991a and *Netastoma* *squiresi* Kennedy, 1993. In addition, the following two species could probably be added to this list. Although the description of the type locality of the bivalve *Venericardia* (*Pacificor*) *susanaensis* Verastegui, 1953, is somewhat vague, this locality is most likely in the upper 100 m of the formation. As will be discussed under "Age," the type locality of the gastropod *Turritella* *andersoni* *susanae* was reported (Merriam, 1941) from the basal part of the Lajas Formation, but the actual stratigraphic position of this locality is probably in the upper 100 of the Santa Susana Formation.

AGE

The upper 100 m of the Santa Susana Formation is latest Paleocene through earliest Eocene ("Meganos Stage") in age, based on calcareous nannofossils, mollusks, sporomorphs, and magnetostratigraphy. Assignments to the calcareous nannofossil biozones and provincial Pacific coast of North America lower Paleogene molluscan stages are shown in Figure 2.

The term "Meganos Stage" stems from Clark

(1918), and the type section of this stage is in the Deer Valley area north of Mount Diablo, Contra Costa County, northern California, where Clark (1918, 1921) subdivided the Meganos Formation into five major lithologic members. Starting at the base, he designated the members as Divisions A, B, C, D, and E. The molluscan fauna from this series, which was studied in detail by Clark and Woodford (1927), comes from Division D. Almgren et al. (1988: fig. 4) assigned Division D strata of the Meganos Formation to the CP9 Zone (lowest Eocene) of the standard calcareous nannofossil zonation. Most of the "Meganos Stage" correlates with the CP9 Zone, but the lower part of the stage correlates to the CP8 Zone (uppermost Paleocene). The age of the "Meganos Stage," therefore, corresponds to the latest Paleocene to earliest Eocene (Saul, 1983; Squires, 1988a, 1997). Modern workers now refer to the strata of Division D of the Meganos Formation as the Margaret Hamilton Sand (Edmondson, 1984).

Filewicz and Hill (1983:fig. 5) reported calcareous nannofossils diagnostic of the lower Eocene *Discoaster diastypus* (CP9) Zone of the standard calcareous nannofossil zonation from siltstones immediately below the upper 100 m of the Santa Susana Formation on the north side of Simi Valley. The upper 100 m on the north side of Simi Valley are barren of any calcareous nannofossils (Filewicz and Hill, 1983), as well as any planktonic foraminifera (Heitman, 1983). Filewicz and Hill (1983) did not study the upper 100 m of this formation on the south side of Simi Valley. In the course of this present study, I collected 12 microfossil samples from the upper 100 m of the Santa Susana Formation on the south side of Simi Valley. The calcareous nannofossils are rare, poorly preserved, and, as with those from the north side of Simi Valley, only present near the bottom of the 100-m-thick interval, where the siltstone content is higher. Only two samples, those from CSUN localities 1342 and 1343, yielded any calcareous nannofossil data pertinent to geologic age determination. Both samples yielded a late Paleocene age, probably equivalent to the *Discoaster multiradiatus* (CP8) Zone of the standard calcareous nannofossil zonation (M. V. Filewicz, personal communication). No planktonic foraminifera were recovered from any of the 12 microfossil samples (H. L. Heitman, personal communication).

As mentioned earlier, the stratigraphic nomenclature of the upper part of the Santa Susana Formation in the Simi Valley area has been confusingly inconsistent. Similarly, the concept of the "Meganos Stage" in this area has lacked biostratigraphic precision. Saul's (1983) study of the turritellas and venericardias in the various Paleogene formations in the Simi Valley area helped greatly in clarifying the proper assignment of provincial molluscan stages to these formations. She reported that *Turritella andersoni* *susanae*, *T. uvasana infera*, *T. meganosensis* Merriam, 1941 and *Venericardia* (*Pacificor*)

hornii susanaensis are important megafaunal components of the upper 100 m of the Santa Susana Formation and enable correlation of these rocks to the northern California-based concept of the "Meganos Stage." *Turritella meganosensis*, furthermore, is also found at the type section (Margaret Hamilton Sand) of this stage in northern California. *Turritella andersoni susanae* is locally plentiful in the upper 100 m of the formation and is probably confined to the "Meganos Stage." A single specimen, which is the holotype of this gastropod, however, was reported from the basal part ("Capay Stage") of the overlying Lajas Formation on the north side of Simi Valley. It seems highly probable that the stratigraphic position of this locality is in error, and that the holotype is actually from the upper part of the Santa Susana Formation. *Turritella wasana infera* is found in both the "Meganos Stage" and in the overlying "Capay Stage."

The only well-described (Clark and Woodford, 1927) megafauna of "Meganos" age is that of the Margaret Hamilton Sand at the type section of the "Meganos Stage" in Deer Valley, Contra Costa County, although strata ("Meganos Formation") of this age are also known from south of Round Valley on the Middle Fork of Eel River in Mendocino County, northern California. Other than *Turritella meganosensis*, species found in both the Margaret Hamilton Sand and the upper 100 m of the Santa Susana Formation are *Calyptrea diegoana* (Conrad, 1855) [= *Calyptrea* (*Galerus*) *calabasaensis* Nelson, 1925], *Brachysphingus mammillatus* Clark and Woodford, 1927, *Nuculana* (*Sacella*) *gabbii* (Gabb, 1869) [= *Leda gabbii* (Gabb, 1869)], and *Schizaster diabloensis* Kew, 1920. *Gemmula* sp., aff. *G. diabloensis* Clark and Woodford, 1927 from the upper 100 m of the Santa Susana Formation has close affinity to *G. diabloensis* from the Margaret Hamilton Sand.

Frederickson (1983) reported early Eocene sporomorphs from the upper 100 m of the Santa Susana Formation on the north side of Simi Valley. The presence of these early Eocene sporomorphs is best documented near the top of the upper 100 m of the formation.

Bottjer et al. (1991) reported that, in terms of magnetostratigraphy, the lowermost part of the upper 100 m of the Santa Susana Formation on the north side of Simi Valley is correlative to Chron C24R, which is equivalent to an interval that encompasses the Paleocene-Eocene boundary (Berggren et al., 1995).

Simi Valley is part of the Western Transverse Ranges tectonic block, which has been rotated by Neogene displacements. Before rotation, this block lay adjacent to San Diego and Anaheim in southern California. During the Miocene, the block was rotated clockwise. Its northern end (which included Simi Valley) acted as the pivotal area and remained essentially in place (Atwater, 1998). The Eocene paleolatitude of the Simi Valley area, therefore, was probably not much different than it is today. De-

position of the upper 100 m of the Santa Susana Formation was also coincident with an overall global sea-level rise (supercycle TA2 of Haq et al., 1987).

The latest Paleocene to earliest Eocene age ("Meganos Stage") of the upper 100 m of the Santa Susana Formation corresponds to an absolute age of 53 to 55 Ma (Berggren et al., 1995). Based on their presence in the upper 100 m of the Santa Susana Formation, the molluscan-stage ranges of nine species can be extended downward to the "Meganos Stage." These species are: *Velates perversus* (Gmelin, 1791), *Pachycrommium clarki* (Stewart, 1927), *Architectonica* (A.) *llajasensis* Sutherland, 1966, *Cylichnina tantilla* (Anderson and Hanna, 1925), *Spondylus carlosensis* Anderson, 1905, *Macoma rosa* Hanna, 1927, *Pitar wasana coquillensis* Turner, 1938, *Corbula* (*Caryocorbula*) *dickersoni* Weaver and Palmer, 1922, and *Corbula* (*Caryocorbula*) *parilis* Gabb, 1864. Similarly, the presence of *Astrocoenia* sp. and *Pycnodonte* (*Phygraea*) sp., aff. *Pycnodonte* (*Phygraea*) *pacifica* Squires and Demetron, 1990, in the upper 100 m of the formation represents the earliest occurrences of *Astrocoenia* and *Phygraea* in the Paleogene rock record of the Pacific coast of North America.

The molluscan-stage ranges of three species in the study area can be extended upward from the Paleocene "Martinez Stage" to the "Meganos Stage." These species are: *Ringicula* (R.) *pinguis* (Gabb, 1864), *Saulella undulifera* (Gabb, 1869), and *Cyclocorystes aldersoni* Squires, 1980.

PALEOCLIMATE AND PALEOBIOGEOGRAPHY

As reviewed by Squires (1987), the world climate was relatively warm and equable during most of the Paleocene through early middle Eocene time, and a worldwide late Paleocene warming trend culminated in a period of peak warming during the early Eocene. Also reviewed by Squires (1998), during late Paleocene to early middle Eocene time, humid tropical climatic conditions were prevalent in coastal-lowland areas from Baja California, Mexico, to southwestern Washington.

Megafossils in the upper 100 m of the Santa Susana Formation strongly support the presence of tropical waters. The hermatypic colonial coral genus *Astrocoenia* lives today only in the West Indies and is a reef dweller in shallow, tropical seas (Durham, 1942). Although Paleocene and early Eocene reef corals seldom formed true reefs, by middle through late Eocene times they started to build reefs, and *Astrocoenia* was one of these reef builders in the Caribbean region (Budd et al., 1992). The extinct gastropod genus *Corsania* is indicative of warm climate (Saul and Squires, 1997), and modern *Campanile* is also indicative of warm waters and very shallow depths (Squires, 1993). The bivalve *Arca* s.s. most frequently inhabits tropical waters today (Keen, 1971; Abbott and Dance,

1982), and the same is true of the bivalves *Spondylus* (see Squires, 1984:table 5) and *Fimbria* (see Nicol, 1950).

The late Paleocene and early Eocene were times of major immigration of Old World Tethyan megainvertebrates into the Pacific coast region of North America via a seaway, most likely through the Central America seaway (Clark and Vokes, 1936; Givens, 1978, Zinsmeister, 1983a; Squires, 1984, 1987). One of the most important of these is the gastropod *Velates perversus*, which dispersed westwardly from Pakistan into California (Squires, 1987; Squires and Demetron, 1992). The new occurrence of this species in the "Meganos"-age upper 100 m of the Santa Susana Formation provides it with a slightly earlier arrival date in California.

Additional mollusk taxa in the upper part of the Santa Susana Formation that have been recognized as Tethyan or of Tethyan affinity (Clark and Vokes, 1936; Squires, 1984; 1987, 1990, 1991a; Givens, 1989) and must have accompanied *Velates perversus* into the waters of the Pacific coast of North America are *Pachycrommium*, *Arca* s.s., and *Fimbria*. Although *Campanile* is also indicative of Old World Tethyan connections, this genus had already arrived onto the Pacific coast region by the late Paleocene ("Martinez Stage") (Squires, 1993).

As will be indicated in the "Systematics" section, some other megafossils found in the upper part of the Santa Susana Formation are strongly suggestive of Old World Tethyan connections. The octocoral ?*Mopsea* sp., aff. *M. costata* Milne-Edwards and Haime, 1850 is remarkably similar to *M. costata* from the lower Eocene London Clay in southern England. The crab *Cyclocorystes aldersoni* Squires, 1980 is most similar to *C. pulchellus* Bell, 1858, also from the lower Eocene London Clay. *Cyclocorystes* is only known from these two species. The gastropod ?*Ancillarina* sp., which might be the only known record of this genus in the Western Hemisphere, is most similar to *A. canalifera* (Lamarck, 1802) from the Paris Basin, France.

SYSTEMATIC MATERIALS AND METHODS

Systematic arrangement of the higher taxa follows that of Bayer (1956) for the octocoral, Wells (1956) for the scleractinians, Vokes (1980) for the bivalves, and Glaessner (1969) for the crabs. The higher classification of gastropods is in a state of flux, and some of the categories used here for suprafamilial names are referred to as superorders and generally correspond to major clade names used by Ponder and Lindberg (1996, 1997).

Synonymies (primarily including only figured specimens), primary type material, molluscan stage range, and geographic distribution data are given for the identifiable species. Terms used to denote specimen abundance are defined as follows (number of specimens in parentheses): rare (1-4), uncommon (5-9), common (10-29), and abundant (30 or more). Abbreviations for catalog and/or locality numbers are:

ANSP: Academy of Natural Sciences, Philadelphia

ANSP CAS: California Academy of Sciences, San Francisco
ANSP CSUN: California State University, Northridge
ANSP LACMIP: Natural History Museum of Los Angeles County, Invertebrate Paleontology Section
ANSP UCMP: University of California, Museum of Paleontology, Berkeley
ANSP UCR: University of California, Riverside
ANSP USNM: United States National Museum, Washington, D.C.

The bulk of the collections used in this study are housed at CSUN. New species primary type material and hypotypes of the invertebrates used for illustrations in this report are deposited at LACMIP.

SYSTEMATICS

Phylum Cnidaria Hatschek, 1888

Class Anthozoa Ehrenberg, 1834pqc

Subclass Octocorallia Haeckel, 1866

Order Gorgonacea Lamouroux, 1816

Family Isididae Lamouroux, 1812

Genus *Mopsea* Lamouroux, 1816

TYPE SPECIES. *Isis dichotoma* Linnaeus, 1758, by subsequent designation Milne-Edwards and Haime, 1850; Recent, Antarctica.

?*Mopsea* sp., aff. *M. costata* Milne-Edwards and Haime, 1850

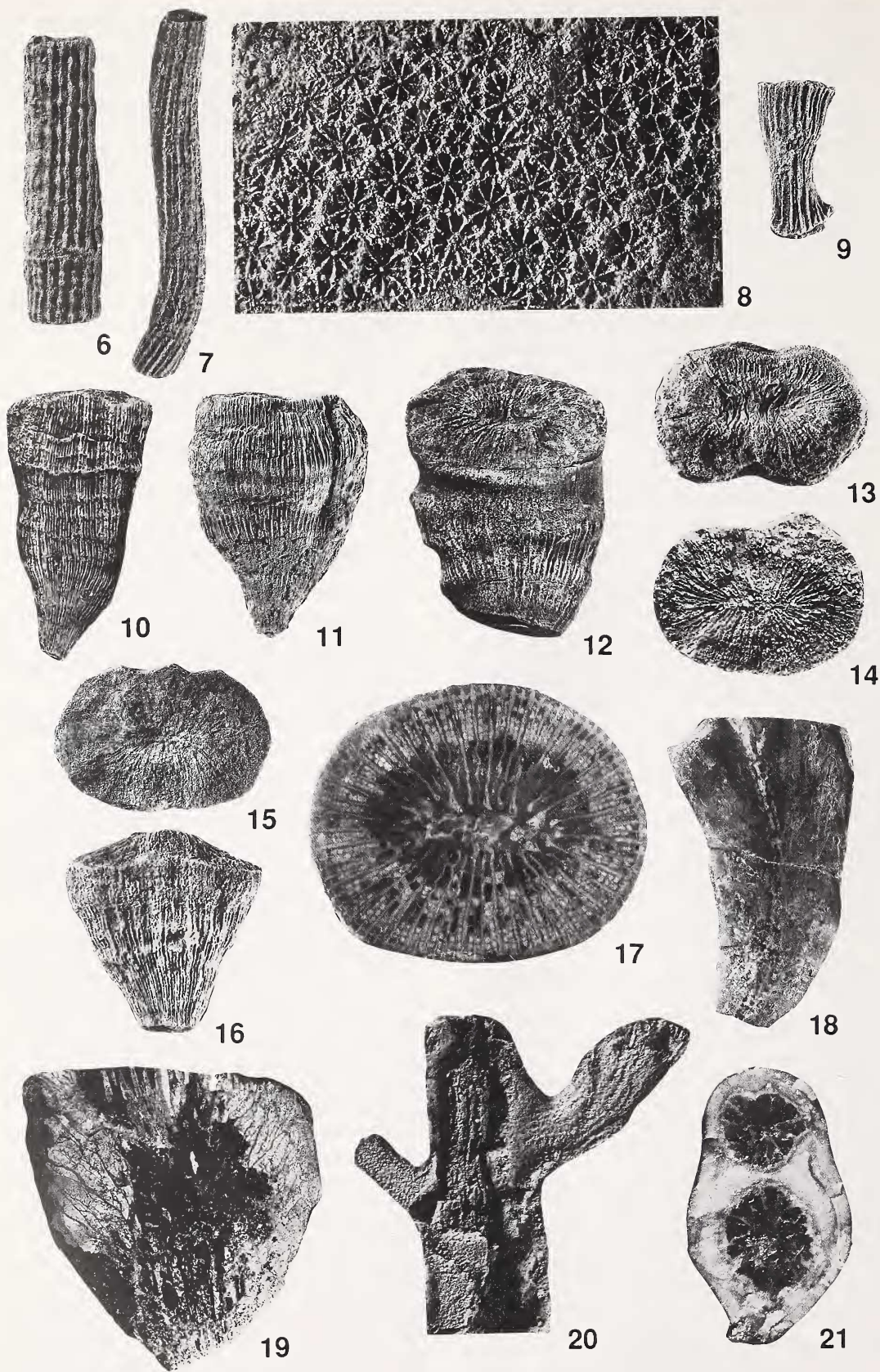
Figures 6, 7

LOCAL OCCURRENCE. CSUN loc. 1343.

REMARKS. Twenty-six fragments were collected, and they consist of straight-to-curved, cylindrical calcareous internode axial stems up to 23 mm long. The stems are longitudinally marked by closely spaced ribs that bear small spines.

Few published reports exist describing fossil octocoral remains. The isidid octocorals are probably the most common forms preserved because of extensive calcification of the axis (Kocurko, 1988). Unfortunately, generic determinations of isidid octocorals cannot be reliably made using only calcareous internode-stem material. Soft-part morphology and microscopic spicular material are also needed (Bayer, 1956, and personal communication).

The Santa Susana Formation specimens are remarkably similar to the calcareous axial parts of *Mopsea costata* Milne-Edwards and Haime, 1850, from the lower Eocene London Clay in southern England. The Santa Susana Formation specimens differ from *M. costata* Milne-Edwards and Haime (1850:42, pl. 7, figs. 3, 3a) only by having more elongate spines. To a slightly lesser degree, the Santa Susana Formation specimens also resemble *Mopsea encrinula* (Lamarck, 1815) that lives today in New Caledonian waters. The Santa Susana Formation specimens differ from *M. encrinula*, which



has been illustrated by Bayer and Stefani (1987:65–66, pl. 21, figs. 1–2), by having more closely spaced ribs that bear blunter spines.

The Santa Susana Formation specimens of ?*Mopsea* sp., aff. *M. costata* represent the first record of an isidid octocoral from Paleogene rocks on the Pacific coast of North America. The only other reported octocoral from this region is the parisidid *Parisis batequensis* Squires and Demetron, 1992, found in the lower Eocene part of the Bateque Formation of Baja California Sur, Mexico.

Subclass Zoantharia Blainville, 1830

Order Scleractinia Bourne, 1900

Family Astrocoeniidae Koby, 1890

Genus *Astrocoenia* Milne-Edwards and Haime, 1848

TYPE SPECIES. *Astrea numisma* Defrance, 1826, by monotypy; upper Eocene (lower Bartonian Stage), Gap, southeastern France (Maritime Alps).

Astrocoenia sp.

Figure 8

LOCAL OCCURRENCE. CSUN loc. 1342.

REMARKS. Only a small fragment of a hemispherical colony was found. The fragment, which is weathered and possibly worn, is 40 mm long, 20 mm wide, and approximately 5 mm thick. The corallites are mostly filled with hard matrix, but some of them have been etched by weathering. The corallites are polygonal in shape, and the inside diameter of the calices are up to 1.75 mm. The thecal walls are about 0.25 mm thick, and their upper surfaces are irregular with short protuberances. The calices have two cycles of septa, octamerally arranged in two subequal groups. The first cycle consists of very thin septa that extend to the styliform columella, which appears in the bottom of the calice as a tubercle. The upper margins of these septa are beaded. The septa in the second cycle are very short and rudimentary, consisting of trabecular spines projecting inward from the thecal walls.

The presence of *Astrocoenia* sp. in the upper 100

m of the Santa Susana Formation represents the earliest record of this genus on the Pacific coast of North America and its first record in the “Meganos Stage.” Only two other species of *Astrocoenia* have been reported from this region. One is *Astrocoenia* sp., aff. *A. portoricensis* Vaughan, 1919, from middle lower Eocene (“Capay Stage”) strata in the *Turritella uvasana infera* fauna of the Juncal Formation in the Whitaker Peak area, Ventura County, California. Squires (1987:19, fig. 6) described and illustrated a specimen from the Juncal Formation. *Astrocoenia* sp. from the Santa Susana Formation differs from the Juncal Formation species by having larger corallites, by the presence of secondary septa, and by having eight primary septa. The Juncal Formation species usually has eight primary septa, but rare specimens can have 10 primary septa.

The other species of *Astrocoenia* reported from the Pacific coast of North America fossil record is *A. dilloni* Durham (1942), from lower Eocene “Capay Stage” and possibly “Domengine Stage” strata on the south side of the headwaters of Media Aqua Creek, Kern County, California (Durham, 1942) and from lower Eocene “Capay Stage” strata in the Bateque Formation of Baja California Sur, Mexico (Squires and Demetron, 1992). *Astrocoenia* sp. differs considerably from *A. dilloni* Durham (1942: 505, pl. 44, fig. 3; Squires and Demetron, 1992: 17, fig. 26) by having only eight rather than 10 septa and by having much weaker secondary septa.

Lower Tertiary astrocoenids are better represented in the Caribbean Sea region than on the Pacific coast region of North America. Of the various fossil astrocoenids reported by Duncan (1873), Vaughan (1919), Wells (1934, 1945), Frost and Langenheim (1974), and Budd et al. (1992) from the Caribbean region, *Astrocoenia* sp. is most similar to *A. jukesbrownei* Wells, 1945, and *A. incrustans* (Duncan, 1873) [= *A. guantanamoensis* Vaughan, 1919]. These two species are discussed below.

Astrocoenia jukesbrownei Wells (1945:3–4, pl. 1, figs. 4, 5; Budd et al., 1992:575, fig. 2.9–2.10), is known from middle Eocene strata in Barbados and upper Eocene strata in Panama. *Astrocoenia* sp. differs from *A. jukesbrownei* by having thinner thecal

←

Figures 6–21. Octocoral, colonial corals, and solitary coral from the upper 100 m of the Santa Susana Formation, Simi Valley. All specimens coated with ammonium chloride, unless otherwise noted. 6, 7. Octocoral? *Mopsea* sp., aff. *M. costata* Milne-Edwards and Haime, 1850, CSUN loc. 1343. 6. Side view, $\times 3.9$, LACMIP hypotype 12661. 7. Side view, $\times 3.3$, LACMIP hypotype 12662. 8. Colonial coral. *Astrocoenia* sp., dorsal view of corallum, $\times 4.3$, LACMIP hypotype 12663, CSUN loc. 1342. 9–19. Solitary coral? *Antillophyllia californica* new species, adult specimens unless otherwise noted, CSUN loc. 1343. 9. Lateral view of juvenile showing basal attachment area, $\times 2.1$, LACMIP paratype 12665. 10. Lateral view, $\times 0.9$, LACMIP paratype 12666. 11. Lateral view, $\times 1.1$, LACMIP paratype 12667. 12. Lateral view, $\times 1.4$, LACMIP paratype 12668. 13. Lateral view, $\times 1.2$, LACMIP paratype 12669. 14. Lateral view, $\times 1.5$, LACMIP paratype 12670. 15, 16. LACMIP holotype 12664, $\times 1.3$. 15. Dorsal view. 16. Lateral view. 17. Uncoated, polished section, transverse view through lower fossa area, $\times 3.9$, LACMIP paratype 12671. 18. Uncoated, polished section, longitudinal view through columella, $\times 2$, LACMIP paratype 12672. 19. Photomicrograph, longitudinal view through columella, $\times 2$, LACMIP paratype 12673. 20, 21. Colonial coral. *Archohelia clarki* Vaughan, 1927, CSUN loc. 1348. 20. Lateral view, $\times 5.2$, LACMIP hypotype 12674. 21. Dorsal view, $\times 4$, LACMIP hypotype 12675.

walls and shallower calices. *Astrocoenia incrustans* (Duncan, 1873:554, pl. 20, fig. 6; Budd et al., 1992:575, fig. 2.6–2.8) is known with certainty from middle Eocene strata in Cuba, St. Bartholomew, and Chiapas, Mexico; upper Eocene strata in Cuba and Antigua; and middle Miocene strata in Panama (Budd et al., 1992). *Astrocoenia* sp. differs from *A. incrustans* by having much weaker secondary septa and no secondary septa that extend to the columella. The relation of *Astrocoenia* sp. to these two species, as well as to other early Tertiary astrocoenids of similar size, growth habit, septal number, and calicular structure, needs to be clarified. More specimens and better preserved material of *Astrocoenia* sp. are needed to fully describe the external and internal features. Only then will it be possible to determine whether this astrocoenid represents a new species.

Family Faviidae Gregory, 1900

Genus *Antillophyllia* Vaughan, 1932

TYPE SPECIES. *Antillia lonsdaleia* Duncan, 1864, by original designation; Miocene, Dominican Republic.

?*Antillophyllia californica* new species

Figures 9–19

DIAGNOSIS. *Antillophyllia*-like with a shallow fossa, a columella usually trabecular below and sublamellar or nearly indiscernible above, a synapticalate corallum wall, and a corallum with prominent girdling bands.

COMPARISON. The new species is most similar to ?*Antillophyllia olssoni* Clark and Durham (1946) from upper Eocene strata in Colombia. The similarity between the new species and ?*A. olssoni* Clark and Durham (1946:80, pl. 25, figs. 8, 9) is strong in terms of the large size of the corallum, the prominent costae corresponding to septa, the presence of a ring of synapticalae inside the wall, and thickened inner ends of the septa near the columella. The new species differs from ?*A. olssoni* by having a slightly smaller size, a narrower base to the corallum, a narrower columellar region, and the presence of swollen, girdling bands on the corallum.

The new species is most similar to *Antillophyllia sawkinsi* (Vaughan in Vaughan and Hoffmeister, 1926) from the uppermost Oligocene and lower Miocene La Quinta Formation in Chiapas, Mexico, and lower Miocene strata (apparently the Brasso Formation) in Trinidad (Frost and Langenheim, 1974). The swollen, girdling bands on the corallum of the new species are similar to those reported by Frost and Langenheim (1974) as epithelial bands on specimens of *A. sawkinsi*. The new species differs from *A. sawkinsi* (Vaughan in Vaughan and Hoffmeister, 1926:118, pl. 2, figs. 6, 6a; Wells, 1934:pl. 28, figs. 6, 6a; Vaughan and Wells, 1943:fig. 305, 3a–3b; Frost and Langenheim, 1974:282, 285, pl.

106, figs. 3–8, pl. 108, figs. 1–8) by having a narrower base, an elevated fossa (at least on some specimens), and a columella that is trabecular below and sublamellar above. Frost and Langenheim (1974) reported that *A. sawkinsi* is closely related to ?*Antillophyllia olssoni* Clark and Durham. Frost and Langenheim (1974) did not questionably assign Clark and Durham's species to *Antillophyllia*, although Clark and Durham (1946) originally did question the generic assignment.

?*Antillophyllia californica* new species superficially resembles ?*Trochocyathus striatus* (Gabb, 1864) reported (Squires, 1984) from the middle Eocene ("Domengine Stage") part of the Lajas Formation on the north side of Simi Valley. The new species differs from ?*T. striatus* (Gabb, 1864:207–208, pl. 26, fig. 195; Squires, 1984:14, fig. 5c) by having a larger size, a more compressed corallum, much shallower fossa, many more septa, narrower costae, a more horizontally elongate columella, and girdling bands on the corallum. In addition, the new species has no confirmed presence of pali, whereas ?*T. striatus* has pali.

DESCRIPTION. Solitary, trochoid (basal angle approximately 40 degrees) to subtrubinate, up to 50 cm in height and 2.5 cm in diameter. A few specimens moderately curved (ceratoid) and enlarging rapidly. Rare specimens bilobate. Corallum attached in early juvenile stage, with small holdfast conforming in shape to substrate; ?free in mature stage. Corallum external surface of most specimens shows swollen and irregularly spaced, ?epithelial girdling bands (1.5 to 3 mm wide). Corallum costate, septa lowly exsert. Costae tend to alternate in size and correspond to all septal cycles. Calice elliptical to subcircular, usually elliptical. Fossa very small to small, very slightly concave to shallowly concave. Some specimens with an elevated fossa; rare specimens with only a protruding central calice area and no fossa. Columella very shallow to moderately shallow; barely detectable in some specimens (septae nearly fill the columellar area on these specimens). Columella trabecular below and sublamellar above; sublamellar columella usually most obvious on juvenile specimens (less than about 18 mm in height). Wall septothecal? and parathecal (endothecal dissepiments moderately common). Septal margins moderately dentate; synapticalae in corallum wall. Specimens about 22 mm high show five cycles of septa: First cycle (six septa) and second cycle (six septa) reach the columella; third cycle (12 septa) reaches or nearly reaches the columella; fourth cycle (24 septa) 75 to 80% as long as the proseptra of the first cycle; and fifth cycle (48 septa) short and only in the wall. Inner ends of the first through third cycles of septa adjacent to the columella are swollen, and swellings (paliform lobes?) much better developed on juvenile specimens (less than about 18 mm in height).

HOLOTYPE DIMENSIONS. Height 24.3 mm (incomplete), long diameter 23.2 mm, short diameter 15.8 mm.

PRIMARY TYPE MATERIAL. LACMIP holotype 12664 (illustrated), LACMIP paratypes 12665 to 12673 (all illustrated); all types from CSUN loc. 1343.

TYPE LOCALITY. CSUN loc. 1343.

MOLLUSCAN STAGE RANGE. “Meganos.”

GEOGRAPHIC DISTRIBUTION. South side of Simi Valley, California.

LOCAL OCCURRENCE. CSUN loc. 1343.

REMARKS. Specimens are abundant (155 collected) and show a growth series that grades from juvenile (8 mm in height) to very mature adult (5 cm in height). The base of nearly every specimen is missing, but one juvenile (Fig. 9) shows a small holdfast. Although weathering has affected all specimens, external preservation is generally good. On many specimens, however, the fossa area and the corresponding septa have been crushed, infilled with difficult to remove, well-cemented mudstone, or both. In addition, no specimen is preserved well enough in the fossa area to determine whether the swollen inner ends of the major septa truly correspond to paliform lobes. One of the main diagnostic features of genus *Antillophyllia* is having paliform lobes, and until better preserved specimens are found, the new species can only be questionably assigned to this genus. Recrystallization and crushing have obscured much of the internal features of the specimens of the new species. There are “ghost structures” that resemble septothecate structures, and many of the dissepiments have been obliterated.

Antillophyllia was reported previously only from upper Eocene strata in Colombia, South America, Oligocene and Miocene strata in Chiapas, Mexico, and lower Miocene strata in Trinidad and Florida (Clark and Durham, 1946; Weisbord, 1971; Frost and Langenheim, 1974). If the new species does belong to this genus, it would be the earliest and westernmost occurrence of *Antillophyllia*.

ETYMOLOGY. The new species is named for the state of California.

Family Oculinidae Gray, 1847a

Genus *Archohelia* Vaughan, 1919

TYPE SPECIES. *Archohelia limonensis* Vaughan, 1919, by original designation; Pliocene, Costa Rica.

Archohelia clarki Vaughan, 1927

Figures 20, 21

Archohelia clarki Vaughan, 1927:143, pl. 23, figs. 1–5.

PRIMARY TYPE MATERIAL. UCMP holotype 31414 and UCMP paratype 31415; exact location unknown, “Meganos Formation,” north of Mt. Diablo, Contra Costa County, California.

MOLLUSCAN STAGE RANGE. “Meganos.”

GEOGRAPHIC DISTRIBUTION. South side of Simi Valley, California, and north of Mt. Diablo, Contra Costa County, California.

LOCAL OCCURRENCE. CSUN loc. 1348.

REMARKS. Two specimens were found. After removal from the enclosing rock, their state of preservation is somewhat poor. Nevertheless, parts of the specimens show the branching, colonial form and the septa. *Archohelia clarki* is the only known species of this oculinid coral genus from the fossil record of the North American Pacific coast.

Prior to this present study, *Archohelia clarki* was only known from its type locality north of Mt. Diablo in Contra Costa County, California.

Phylum Mollusca Linnaeus, 1758

Class Gastropoda Cuvier, 1797

Superorder Neritopsina Cox and Knight, 1960

Family Neritidae Rafinesque, 1815

Genus *Velates* Montfort, 1810

TYPE SPECIES. *Nerita perversa* Gmelin, 1791, by original designation and monotypy; Eocene, Paris Basin, France.

Velates perversus (Gmelin, 1791)

Figures 22, 23

Nerita perversa Gmelin, 1791:3686.

Velates perversus (Gmelin). Cox, 1931:36–37; Vokes, 1935:382–383, pl. 25, figs. 1–5; pl. 26, figs. 1–2; Clark and Vokes, 1936:875, pl. 1, figs. 7–8; Givens, 1974:61, pl. 5, figs. 5–6, 13; Squires, 1984:16–17, figs. 6b–c; 1987:23–24, figs. 15–19; 1991b:pl. 1, figs. 10, 11; Woods and Saul, 1986:643–647, figs. 4.17, 5.20, 5.22–5.25, 6.1–6.3, 6.8; Squires and Demettrion, 1992:26, figs. 55, 56.

PRIMARY TYPE MATERIAL. Lamarck’s Cabinet in the Natural History Museum of Geneva, Switzerland.

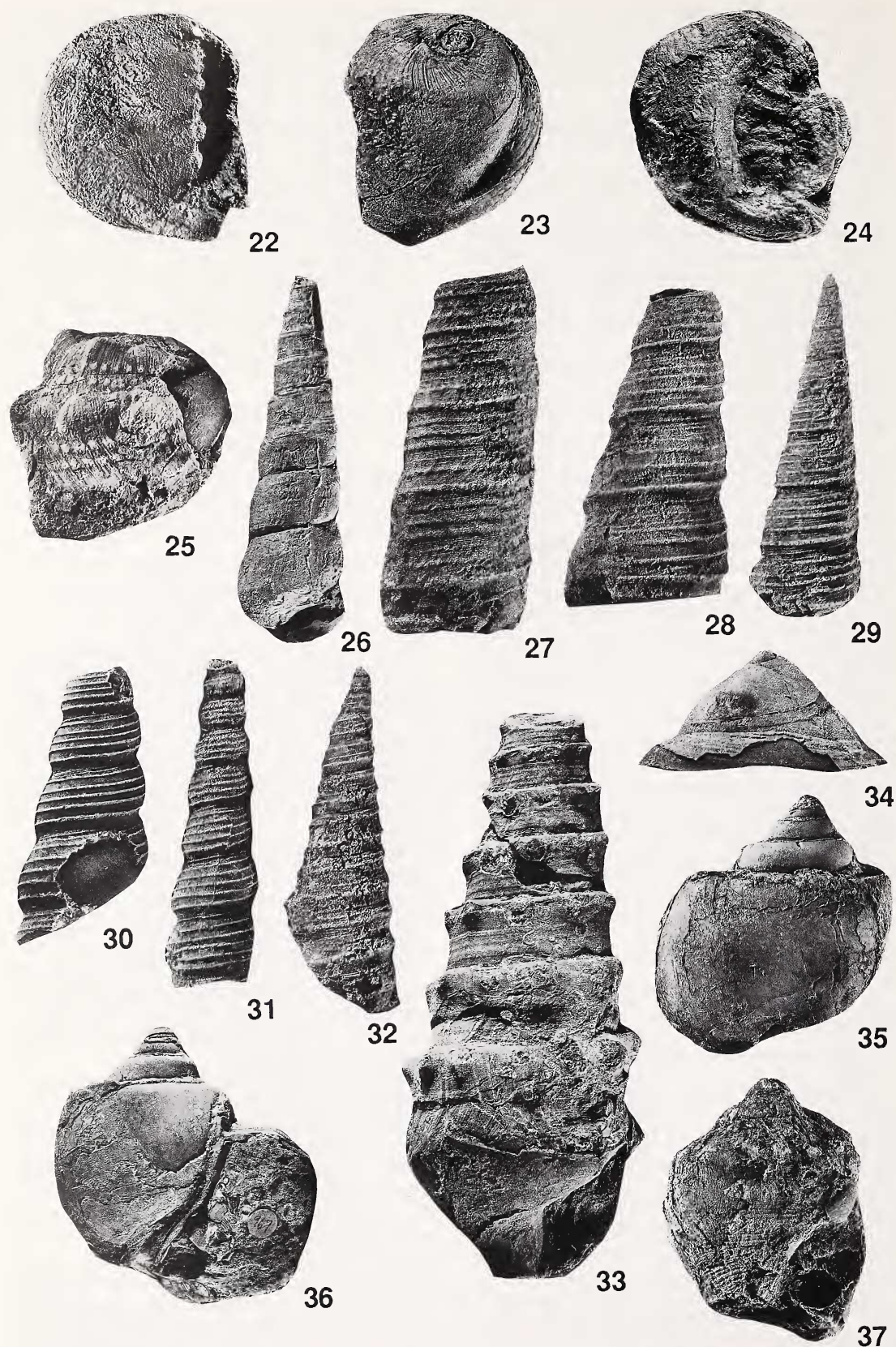
MOLLUSCAN STAGE RANGE. “Meganos” and “Capay,” possibly “Domengine.”

GEOGRAPHIC DISTRIBUTION. Pakistan, India, Myanmar, Tibet, Middle East, northern Africa, western Europe, Florida, ?Panama, Baja California Sur (Mexico), and southern California (possibly south-central California).

LOCAL OCCURRENCE. CSUN loc. 1342, LACMIP loc. 7124.

REMARKS. Two specimens were found. One, from CSUN locality 1342 is a large internal mold, but the diagnostic teeth on the inner lip are visible. The second specimen, from LACMIP locality 7124, is small, but it has the shell and shows all the diagnostic morphology.

See Squires (1987) for a more complete synonymy of this cosmopolitan species. The synonymy given here is primarily for the Pacific coast of North America. This is the first report of *Velates perversus* from the “Meganos Stage.” In the Simi Valley area, it is also known from low in the Lajas Formation



in "Capay Stage" rocks (Squires, 1984; Woods and Saul, 1986).

The only other species of *Velates* in the Simi Valley area is *V. californicus* Vokes (1935), which has been found at UCMP localities 7009 and 3792 (Vokes, 1935), as well as at LACMIP locality 23173 (Saul, 1983; Woods and Saul, 1986). The stratigraphic position of UCMP locality 7009 is known (Fig. 1), and is approximately on strike with that of LACMIP locality 7124 (Fig. 4). The stratigraphic positions of UCMP locality 3792 and LACMIP 23173, however, are not known. These two localities are probably in the upper part of the Santa Susana Formation on the south side of Simi Valley, and the specimens are probably late Paleocene in age (Woods and Saul, 1986).

Although *Velates californicus* and *V. perversus* might have the same geologic range (late Paleocene to early Eocene), they have never been collected at the same locality. As Woods and Saul (1986) reported, *V. californicus* always occurs stratigraphically below *V. perversus*, and the present study confirms this observation.

Genus *Corsania* Vidal, 1917

TYPE SPECIES. *Corsania doubillei* Vidal, 1917, by original designation; late Early Cretaceous (Albian), Cors, Lérída, Spain.

Subgenus *Januncia* Woods and Saul, 1986

TYPE SPECIES. *Corsania (Januncia) janus* Woods and Saul, 1986, by original designation; late Paleocene?, Baja California Sur, Mexico.

Corsania (Januncia) susana Saul and Squires, 1997

Figures 24, 25

Corsania (Januncia) susana Saul and Squires, 1997: 142–143, figs. 28–30.

PRIMARY TYPE MATERIAL. LACMIP holotype 7890, CSUN loc. 969; LACMIP paratype 7891, CSUN loc. 973; LACMIP paratype 6441, CSUN loc. 966. All localities in the upper 100 m

of the Santa Susana Formation, north side of Simi Valley, California.

MOLLUSCAN STAGE RANGE. "Meganos."

GEOGRAPHIC DISTRIBUTION. North side of Simi Valley, California.

LOCAL OCCURRENCE. CSUN locs. 966, 969, 973.

REMARKS. Three specimens were found. Only the holotype shows the inner lip, which is prominently set off from the deck area.

Superorder Caenogastropoda Cox, 1959

Family Turritellidae Woodward, 1851

TYPE SPECIES. *Turbo terebra* Linnaeus, 1758, by monotypy; Recent, southwest Pacific.

Turritella meganosensis Clark and Woodford, 1927

Figure 26

Turritella meganosensis Clark and Woodford, 1927:119–120, pl. 21, figs. 2–5; Merriam, 1941: 75, pl. 8, figs. 3, 4, 7, 9; Saul, 1983:pl. 1, fig. 13; Clark, 1929:pl. 5, figs. 1, 11; Schenck and Keen, 1940:pl. 22, figs. 5–7.

PRIMARY TYPE MATERIAL. UCMP holotype 12445 and UCMP paratype 12441, UCMP loc. 3159, Margaret Hamilton Sand [= Clark and Woodford's (1927) Division D of the Meganos Formation], Deer Valley, Contra Costa County, California; paratypes UMCP 31225–31226, UCMP loc. 7000, upper Santa Susana Formation, north side of Simi Valley, California.

MOLLUSCAN STAGE RANGE. "Meganos."

GEOGRAPHIC DISTRIBUTION. North side of Simi Valley, California; Deer Valley, Contra Costa County, California; south of Covelo (Round Valley) on Middle Fork of Eel River, Mendocino County, California.

LOCAL OCCURRENCE. Upper 100 m of the Santa Susana Formation (exact location not known).

REMARKS. In the upper 100 m of the Santa Susana Formation, this rare and large-sized turritellid

Figures 22–37. Gastropods from the upper 100 m of the Santa Susana Formation, Simi Valley. All specimens coated with ammonium chloride. 22, 23. *Velates perversus* (Gmelin, 1791), $\times 1.8$, LACMIP hypotype 12676, LACMIP loc. 7124. 22. Apertural view. 23. Abapertural view. 24, 25. *Corsania (Januncia) susana* Saul and Squires, 1997, $\times 1.4$, LACMIP holotype 7890, CSUN loc. 969. 24. Apertural view. 25. Abapertural view. 26. *Turritella meganosensis* Clark and Woodford, 1927, apertural view, $\times 0.7$, UCMP holotype 37430, UCMP loc. 7000. 27. *Turritella andersoni susanae* Merriam, 1941, apertural view, $\times 3.2$, LACMIP hypotype 12677, CSUN loc. 969. 28, 29. *Turritella buwaldana* Dickerson, 1916. 28. Abapertural view, $\times 3.7$, LACMIP hypotype 10434 [= UCLA hypotype 59372], LACMIP loc. 26615. 29. Abapertural view, $\times 4.5$, LACMIP hypotype 12678, CSUN loc. 1343. 30, 31. *Turritella uvasana infera* Merriam, 1941. 30. Abapertural view, $\times 3$, LACMIP hypotype 12679, CSUN loc. 967. 31. Apertural view, $\times 2$, LACMIP hypotype 12680, CSUN loc. 959. 32. *Turritella susanensis* Nelson, 1925 *nomen dubium*, abapertural view, $\times 3.6$, LACMIP hypotype 12681, CSUN loc. 1343. 33. *Campanile dilloni* (Hanna and Hertlein, 1949), apertural view, $\times 0.6$, LACMIP hypotype 12335, CSUN loc. 1565. 34. *Calyptrea diegoana* (Conrad, 1855), lateral view, $\times 2.2$, LACMIP hypotype 12682, CSUN loc. 958. 35, 36. *Pachycrommium clarki* (Stewart, 1927), $\times 0.7$, LACMIP hypotype 12683. 35. Apertural view. 36. Abapertural view. 37. *Phalium (Semicassis) tuberculiformis* (Hanna, 1924), apertural view, $\times 1.7$, LACMIP hypotype 12684, CSUN loc. 967.

(up to 90 mm in height) has been found only at UCMP locality 7000, which is 7.5 m below the Llajas Formation according to Saul (1983). The exact location of this locality, however, is not known. No additional specimens were found during this present study. This species is the only *Turritella* in the upper 100 m of the Santa Susana Formation that is restricted to the "Meganos Stage." Mid-adult stage specimens have a pronounced posterior swelling, but this feature becomes obsolete in late-adult stage specimens (Clark and Woodford, 1927; Merriam, 1941).

Turritella andersoni susanae Merriam, 1941

Figure 27

Turritella andersoni susanae Merriam, 1941:79, pl. 11, fig. 6; Saul, 1983:pl. 2, fig. 5.

Turritella andersoni n. subsp. Saul, 1983:pl. 1, figs. 15–18.

PRIMARY TYPE MATERIAL. UCMP holotype 15295, UCMP loc. A-993, basal Llajas Formation, north side of Simi Valley, California.

MOLLUSCAN STAGE RANGE. "Meganos."

GEOGRAPHIC DISTRIBUTION. Simi Valley, California.

LOCAL OCCURRENCE. CSUN locs. 962, 963, 964, 965, 966, 969, 970, 971, 972, 973, 1347, 1349, LACMIP loc. 21551.

REMARKS. Specimens are abundant at most localities but generally have poor preservation because their weathered shells are chalky and disintegrate when removed from the outcrop. The largest specimens are up to 45 mm in height and were found at locality 966.

This subspecies is characterized by adult whorls with a concave whorl profile bearing two relatively heavy spiral ribs anteriorly (the anteriormost is the most prominent) and two primary spiral ribs posteriorly. All of these ribs can be noded. The medially concave area between these two sets of primary ribs is usually smooth, or, in some cases, with a secondary and numerous tertiary spiral ribs. A sutural spiral rib is also present.

Squires (1984) regarded this subspecies as conspecific with *Turritella andersoni* s.s. Dickerson, 1916. As stated by Merriam (1941), and later confirmed by Squires (1987), the two are separate taxa. *Turritella andersoni susanae* differs from *T. andersoni* s.s. in the relatively stronger development of the two posterior primary spiral ribs. In the synonymy of *T. andersoni* s.s. given by Squires and Goedert (1994), *T. a. susanae* was inadvertently included as a synonym of *T. andersoni*.

Although *Turritella andersoni susanae* is locally abundant and is one of the most diagnostic species of the "Meganos Stage" in the Simi Valley area, the holotype of this subspecies is reported to be from the basal part of the overlying Llajas Formation, at UCMP loc. A-993 on the north side of Simi Valley. The holotype is the only specimen of *T. a. susanae* ever reported from the Llajas Formation, and

Squires (1984), in his monographic work on the Llajas Formation, never encountered any specimens of this subspecies. The description of the type locality is imprecise and could apply equally to the upper 100 m of the Santa Susana Formation or to the lower part of the Llajas Formation. It is likely that the type locality of *T. a. susanae* is in error and should have been reported as from the upper 100 m of the Santa Susana Formation.

Turritella buwaldana Dickerson, 1916

Figures 28, 29

Turritella buwaldana Dickerson, 1916:500–501, pl. 42, figs. 7a–b; Hanna, 1927:307:pl. 19, figs. 7–8, 12; Vokes, 1939:161; Kappeler et al., 1984: table 2; Merriam, 1941:86–87, pl. 21, figs. 3–9; pl. 33, figs. 1–14; Stewart, 1946:pl. 11, fig. 24; Givens, 1974:63, pl. 5, fig. 15; Saul, 1983:pl. 2, figs. 13–15; Squires, 1983a:fig. 9f; 1984:18, fig. 6h; 1987:27, fig. 24; 1988b:10–11, fig. 15; 1991b:pl. 1, fig. 14; Squires and Demetron, 1992:27, fig. 61.

?*Turritella uvasana* Conrad. Dickerson, 1915:pl. 5, figs. 1c, 3, 4.

Turritella kewi Dickerson, 1916:501, pl. 42, fig. 8.

Turritella subuvasana Nelson, 1925:423, pl. 56, figs. 5, 6, 7; Merriam, 1941:74, pl. 41, figs. 1–3.

Turritella buwaldana crooki Merriam and Turner, 1937:105, pl. 5, fig. 6; Merriam, 1941:87, pl. 21, figs. 1, 2; Turner, 1938:85; Vokes, 1939:161–162; Saul, 1983:pl. 2, figs. 2, 3.

Turritella? buwaldana subuvasana Nelson. Saul, 1983:pl. 1, fig. 11.

PRIMARY TYPE MATERIAL. UCMP holotype 12130, UCMP loc. 672, Domingine Formation, Fresno County, California.

MOLLUSCAN STAGE RANGE. "Meganos" through "Tejon."

GEOGRAPHIC DISTRIBUTION. San Ignacio Lagoon area, Baja California Sur, Mexico, to Glide, Oregon.

LOCAL OCCURRENCE. CSUN locs. 958, 959, 961, 962, 967, 970, 972, 1342, 1343, 1345, 1346, LACMIP loc. 26615.

REMARKS. Specimens are rare to common and are most abundant at locality 961. All specimens are fragmentary and show moderately good preservation.

The range of variability of *Turritella buwaldana* is "confusingly great," as noted by Merriam (1941: 86), and he found variation among individuals from the type locality, as well as variation within and among other known regional assemblages. Considerable variation of *T. buwaldana* is also present in specimens found in the upper 100 m of the Santa Susana Formation. Many of the specimens fit the original description of *T. buwaldana* and have three primary spiral ribs on the anterior half of the mature whorls and two (in some cases only one) secondary spiral ribs posterior to the primary ribs. Tertiary ribs, usually only one, are in the

interspaces. There are also rare specimens that have three primary ribs and three secondary ribs. These latter specimens are indistinguishable from *T. buwaldana crooki* Merriam and Turner. In the upper 100 m of the Santa Susana Formation, there are also specimens of *T. buwaldana* whose posterior-most primary rib is only as strong as a secondary rib, thereby producing whorls with two primary ribs and three secondaries.

Some specimens of *Turritella buwaldana* from the upper Santa Susana Formation have minute nodes on the primaries (usually only the posterior-most one) and on the secondaries. Squires (1987, 1988b) and Squires and Demetron (1992) also reported the presence of minute nodes on specimens of this species from elsewhere on the Pacific coast of North America.

Nelson (1925: checklist opposite p. 402) reported *Turritella subuvasana* Nelson, 1925, from UCMP loc. 3791 [= CSUN loc. 1343] in the Santa Susana Formation. Specimens of Nelson's species consist of only the tips (apices) of the shells, even though Merriam (1941) reported that specimens show adult-whorl sculpture. During the present study, about 20 specimens were collected at CSUN locality 1343, and they also consist of only the tips of shells. The largest known specimens of *T. subuvasana* from this locality are only 12 mm in height, and the sculpture on the largest whorls usually consists of five spiral ribs. The two posterior-most ribs can be slightly weaker than the other three, or all can be subequal. The sculptural patterns of the tips of Paleogene turritellas from the Pacific coast of North America are not species specific, but in the case of *T. subuvasana*, the tips are sufficiently close to the variability of *T. buwaldana* to allow identification as *T. buwaldana*. One of these specimens is illustrated in Fig. 29.

Nelson (1925) and Merriam (1941) also reported *Turritella subuvasana* from UCMP loc. 3796 in the Santa Susana Formation. The exact stratigraphic position of this locality, which is the type locality of this gastropod, is not known because of structural complications caused by the nearness of the Runkle Canyon fault zone.

Turritella uvasana infera Merriam, 1941
Figures 30, 31

Turritella uvasana infera Merriam, 1941:90, pl. 40, figs. 2-4; Givens, 1974:65-66, pl. 6, figs. 5-7; Saul, 1983:pl. 1, fig 19; pl. 2, fig. 4; Squires, 1984:19, fig. 6i; 1987:27-28, fig. 25.

PRIMARY TYPE MATERIAL. UCMP holotype 33993, UCMP loc. A-994, lower part of the Lajas Formation, north side of Simi Valley, California.

MOLLUSCAN STAGE RANGE. "Meganos" and "Capay."

GEOGRAPHIC DISTRIBUTION. Simi Valley, Whitaker Peak area, and Pine Mountain area, Ventura County, California.

LOCAL OCCURRENCE. CSUN locs. 959, 960, 961, 967, 1346, LACMIP loc. 21551.

REMARKS. Specimens are rare to abundant, and, at all localities, they are moderately well preserved. They are most abundant at CSUN locality 959. This species is characterized by five equal and strong primary spiral ribs on rounded whorls.

This species has been reported (Merriam, 1941; Givens, 1974; Saul, 1983; Squires, 1984, 1987) as present in the uppermost part of the Santa Susana Formation in the Simi Valley area. Merriam (1941) and Saul (1983) mentioned that these specimens have a more rounded whorl profile and heavier ribbing than those from the type locality low in the overlying Lajas Formation. Squires (1987), however, reported that the upper Santa Susana Formation specimens are indistinguishable from specimens elsewhere.

Turritella susanaensis Nelson, 1925 *nomen dubium*
Figure 32

Turritella susanaensis Nelson, 1925:423, pl. 56, figs. 1, 2; Merriam, 1941:73-74, pl. 41, figs. 4, 10.

REMARKS. Nelson (1925) and Merriam (1941) reported this taxon from the Santa Susana Formation at UCMP loc. 3791 [= CSUN loc. 1343] and UCMP loc. 3796. Specimens are abundant and moderately well preserved at locality 3791. As discussed under *Turritella buwaldana*, the exact stratigraphic position of UCMP loc. 3796 within the Santa Susana Formation is unclear. At both localities, only the broken-off tips of shells have been found, even though Merriam (1941) reported that specimens show adult-whorl sculpture. The largest known specimens are only 13 mm in height.

So far, even after more than 60 years of collecting, only tips of *T. susanaensis* are known. Their sculptural pattern is not distinctive. The sculptural pattern of the tips of Paleocene turritellas from the Pacific coast of North America are, in fact, not species specific. Nelson (1925) should not have based his species on such material; therefore, *T. susanaensis* becomes a *nomen dubium*.

Family Campanilidae Douvillé, 1904

Genus *Campanile* Fischer, 1884

TYPE SPECIES. *Cerithium giganteum* Lamarck, 1804a, by subsequent designation (Sacco, 1895); Eocene, Paris Basin, France.

Campanile dilloni (Hanna and Hertlein, 1949)
Figure 33

Campanilopa dilloni Hanna and Hertlein, 1949: 393, pl. 77, figs. 2, 4, text-fig. 1; Givens, 1974: 69, pl. 7, fig. 10; Squires and Advocate, 1986: 853, 855, fig. 2.1.

Campanile dilloni Hanna and Hertlein. Squires, 1991b:pl. 1, fig. 18; 1993:327–329, figs. 6–11.

PRIMARY TYPE MATERIAL. CAS holotype 9425 and CAS paratypes 9428 and 9429, all from CAS loc. 30667, Mabury Formation, Agua Media Creek, Temblor Range, Kern County, California.

MOLLUSCAN STAGE RANGE. “Meganos” and “Capay.”

GEOGRAPHIC DISTRIBUTION. Orocopia Mountains, Riverside County, California, to Agua Media Creek, Temblor Range, Kern County, California.

LOCAL OCCURRENCE. CSUN loc. 1565.

REMARKS. A single specimen was found. It is 15.1 cm in height and well preserved.

Family Calyptraeidae Lamarck, 1809

Genus *Calyptraea* Lamarck, 1799

Type Species. *Patella chinensis* Linnaeus, 1758, by monotypy; Recent, Europe.

Calyptraea diegoana (Conrad, 1855)

Figure 34

Trochita diegoana Conrad, 1855:7, 17; 1857:327, pl. 5, fig. 42.

Galerus excentricus Gabb, 1864:136, pl. 20, fig. 95; pl. 29, fig. 232a; Arnold, 1907a:pl. 10, fig. 3a.

Calyptraea calabasaensis Nelson, 1925:419, pl. 54, figs. 8a–b.

Calyptraea (*Galerus*) *calabasaensis* Nelson. Clark and Woodford, 1927:120, pl. 21, figs. 10–13.

Calyptraea diegoana (Conrad). Stewart, 1927:340–341, pl. 27, fig. 15; Turner, 1938:89–90, pl. 20, figs. 1–2; Effinger, 1938:378; Weaver, 1943:351–352, pl. 71, figs. 16, 20; pl. 103, fig. 3; 1953:29; Stewart, 1946:pl. 11, fig. 5; Kleinpell and Weaver, 1963:186, pl. 24, fig. 7; Hickman, 1969:79, 82, pl. 11, figs. 7–8; 1980:33–34, pl. 2, figs. 18–21; Deméré et al., 1979:pl. 2, fig. 7; Squires, 1984:21, fig. 6q; 1987:32, fig. 4; 1988b:11, fig. 19; 1991b:pl. 1, fig. 20; 1994:pl. 1, fig. 2; Squires and Goedert, 1994:16, 18, fig. 36.

PRIMARY TYPE MATERIAL. USNM holotype 1856, Eocene strata (probably the Delmar Formation), San Diego, California.

MOLLUSCAN STAGE RANGE. “Martinez” through lower Oligocene.

GEOGRAPHIC DISTRIBUTION. San Diego, California, to Little River area, Grays Harbor County, Washington.

LOCAL OCCURRENCE. CSUN locs. 958, 963, 1342, 1349.

REMARKS. Specimens are rare but moderately well preserved.

Family Naticidae Forbes, 1838

Genus *Pachycrommium* Woodring, 1928

Type Species. *Amaura guppyi* Gabb, 1873, by original designation; Recent, Miocene, Dominican Republic.

Pachycrommium clarki (Stewart, 1927)

Figures 35, 36

Amauropsis alveata (Conrad). Arnold, 1910:pl. 4, fig. 21; Dickerson, 1915:pl. 5, fig. 9; Waring, 1917:pl. 15, fig. 25 [Misidentifications]. Not *Amauropsis alveata* (Conrad, 1855).

Amaurellina (*Euspirocrommium*) *clarki* Stewart, 1927:336–339, pl. 26, figs. 8, 9 [new name, in part, for *Amauropsis alveata* (Conrad, 1855), preoccupied and misidentified]; Clark, 1929:pl. 11, fig. 10; Turner, 1938:86, pl. 20, fig. 3; Weaver, 1943:345, pl. 70, figs. 10, 18; Kleinpell and Weaver, 1963:188, pl. 27, fig. 15.

Amaurellina clarki Stewart. Gardner and Bowles, 1934:246, figs. 6, 8.

?*Amaurellina multiangulata* Vokes, 1939:174, pl. 22, figs. 2, 8, 13.

?*Pachycrommium clarki* (Stewart). Vokes, 1939:175, pl. 22, figs. 11, 30; Givens, 1974:73, pl. 8, figs. 6, 10.

Amaurellina? (*Euspirocrommium*) *clarki* Stewart. Stewart, 1946:pl. 11, fig. 3.

Pachycrommium clarki (Stewart). Marincovich, 1977:238–241, pl. 20, figs. 4–10; Squires, 1983a:fig. 9b; 1984:25, fig. 7e; 1987:36, fig. 44; 1988b:12, fig. 25; 1991b:pl. 1, fig. 25; Squires et al., 1992:pl. 1, fig. 18.

PRIMARY TYPE MATERIAL. UCMP holotype 31385 and UCMP paratype 31386 of *Amaurellina* (*Euspirocrommium*) *clarki* Stewart, both from UCMP loc. 7004, Llajas Formation, north side of Simi Valley, California.

MOLLUSCAN STAGE RANGE. “Meganos” through “Tejon.”

GEOGRAPHIC DISTRIBUTION. Laguna San Ignacio area, Baja California Sur, Mexico, to southwestern Washington.

LOCAL OCCURRENCE. CSUN locs. 958, 967, 1346, 1347.

REMARKS. Specimens are rare to uncommon and most numerous at CSUN locality 967, where they also show the best preservation. This is the first report of this species from the “Meganos Stage.”

Family Cassidae Swainson, 1832

Genus *Phalium* Link, 1807

TYPE SPECIES. *Buccinum glaucum* Linnaeus, 1758, by subsequent designation (Dall, 1909); Recent, Indo-Pacific.

Subgenus *Semicassis* Mörch, 1852

TYPE SPECIES. *Cassis japonica* Reeve, 1848, by subsequent designation (Harris, 1897); Recent, China and Japan.

?*Phalium* (*Semicassis*) *tuberculiformis*
(Hanna, 1924)

Figure 37

LOCAL OCCURRENCE. CSUN loc. 967.

REMARKS. A single specimen was found. It is mostly an internal mold without the outer lip and anterior end of the shell. Some shell is present on the ventral surface, but it is weathered. The specimen has three carinae on the body whorl, and the shell material shows fine spiral ribbing between the carinae. Morphologically, the specimen resembles comparably preserved specimens of *Phalium* (*Semicassis*) *tuberculiformis*, from the “Domengine Stage” “Stewart bed” in the Lajas Formation on the north side of Simi Valley. This similarity is significant enough to warrant tentative identification.

Order Neogastropoda Thiele, 1929

Family Buccinidae Rafinesque, 1815

Genus *Brachysphingus* Gabb, 1869

TYPE SPECIES. *Brachysphingus sinuatus* Gabb, 1869, by subsequent designation (Cossmann, 1901); Paleocene, California and Baja California, Mexico.

Brachysphingus mammilatus Clark and
Woodford, 1927

Figure 38

Brachysphingus mammilatus Clark and Woodford, 1927:116–117, pl. 20, figs. 8–15; Clark, 1929: 13, pl. 4, figs. 3, 10; Schenck and Keen, 1940: 22, figs. 1, 2; Givens, 1974:84, pl. 10, fig. 3; Squires, 1997:856, 858, figs. 5, 1–14.

Pseudoliva sp. Smith, 1975:pl. 1, figs. 14, 15.

PRIMARY TYPE MATERIAL. UCMP holotype 31234 from UCMP loc. 3157; UCMP paratype 31235 from UCMP loc. 3577; UCMP paratype 31236 from UCMP loc. 3159; UCMP paratype 31237 from UCMP loc. 3159, UCMP paratype 31238 from UCMP loc. 3577. All from Margaret Hamilton Sand [= division D of Meganos Formation as used by Clark and Woodford (1927)], Deer Valley, Contra Costa County, California.

MOLLUSCAN STAGE RANGE. “Meganos” and “Capay.”

GEOGRAPHIC DISTRIBUTION. Simi Valley, California, to south of Covelo (Round Valley) on Middle Fork of Eel River, Mendocino County, California.

LOCAL OCCURRENCE. CSUN locs. 958, 1345.

REMARKS. Specimens are rare and well preserved. Squires (1997) did a detailed study of *Brachysphingus*, noting its occurrence in the upper 100 m of the Santa Susana Formation.

Brachysphingus mammilatus has been found associated with *Turritella megalensis* in the area south of Covelo (Round Valley) on the Middle Fork of the Eel River, Mendocino County, California (Merriam and Turner, 1937).

Family Olividae Latreille, 1825

Genus *Ancillarina* Bellardi, 1882

TYPE SPECIES. *Ancilla canalifera* Lamarck, 1802, by subsequent designation (Palmer, 1937); Eocene, Paris Basin, France.

?*Ancillarina* sp.

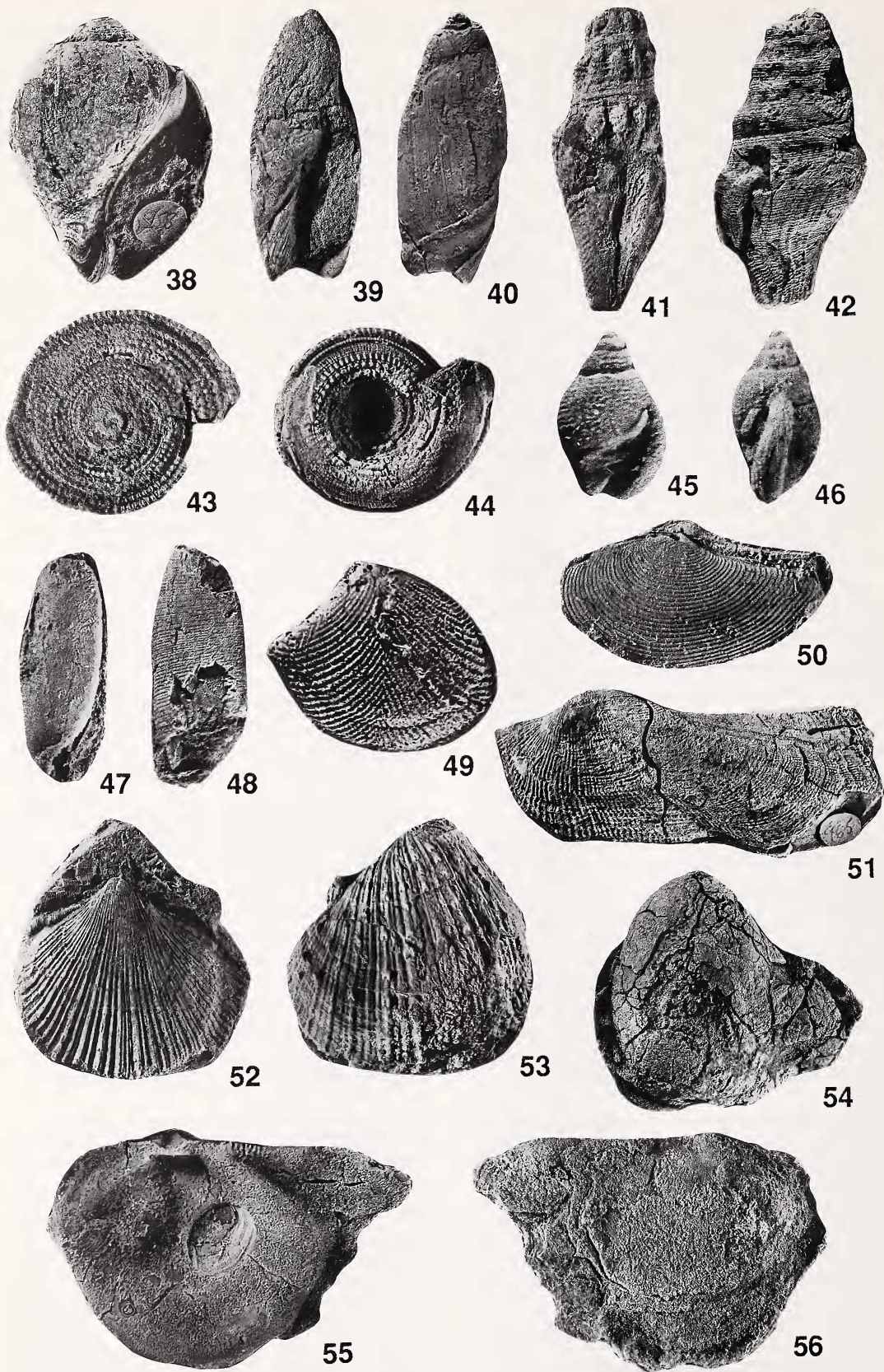
Figures 39, 40

LOCAL OCCURRENCE. CSUN loc. 961.

REMARKS. Three specimens were found. The best preserved of the three is crushed in the middle, and most of the spire is represented as an internal mold. The other two specimens are internal molds. The best preserved specimen is similar in overall shape and in the columella area to the Paris Basin, France, Eocene *Ancillarina canalifera* (Lamarck, 1802). *Ancillarina canalifera*, which is the type species of *Ancillarina*, has a total lack of callus on the spires whorls and sutures, and, according to Kilburn (1981), this is a major diagnostic feature of this genus. The specimen from CSUN locality 961 differs slightly from *A. canalifera* (Lamarck, 1802: 475, pl. 2, fig. 8; Cossmann and Pissarro, 1910–1913:pl. 67, figs. 211–9, 211–9', 211–9"; Kilburn, 1981:figs. 24–27) by having a less distinct suture between the penultimate whorl and body whorl. The somewhat indistinct suture on the specimen from locality 961 might be the result of poor preservation or of a slight amount of callus. Until better preserved specimens are found, it is not possible to assign this species with certainty to *Ancillarina*.

If the specimen from locality 961 does prove to belong to *Ancillarina*, it would be the first record of this genus in the Western Hemisphere. Wenz (1943) reported the temporal range of this genus as Eocene to Miocene and the geographic distribution as confined to Europe.

The specimen of ?*Ancillarina* sp. superficially resembles *Ancilla burroensis* Nelson (1925) from the “Martinez marine member” (“Martinez Stage”) part of the Santa Susana Formation on the south side of Simi Valley. The specimen of ?*Ancillarina* sp. differs from *A. burroensis* Nelson (1925:433, pl. 60, figs. 2, 3) by having columellar teeth that are less prominent, longer, and more parallel to the shell axis, as well as by having a more deeply notched anterior sinus. In addition, if ?*Ancillarina* sp. does have any callus on the spire, it is much lighter than the heavily calloused spire found on *A. burroensis*.



Family Turridae Swainson, 1840

Genus *Gemmula* Weinkauff, 1875

Type Species. *Gemmula hindsiana* Berry, 1958 [= *Pleurotoma gemmata* Reeve, 1843], by subsequent designation (Cossmann, 1896); Recent, southern Baja California, Mexico, to Colombia, South America.

Gemmula sp., aff. *G. diabloensis* Clark and Woodford, 1927

Figure 41

LOCAL OCCURRENCE. CSUN loc. 961.

REMARKS. A single specimen was found, and it is missing the uppermost spire and tip of the anterior canal. About half of the shell material is missing, and the half that present is weathered. The specimen has close affinity to *Gemmula diabloensis* Clark and Woodford (1927:107, pl. 19, figs. 3, 4) from the "Meganos Stage" Margaret Hamilton Sand [= Division D of the Meganos Formation as used by Clark and Woodford, 1927] in Contra Costa County, California. The specimen from CSUN locality 961 differs from *G. diabloensis* by having 12 rather than about 10 axial ribs on the penultimate whorl, three rather than four spiral ribs between the shoulder angulation and the sutural collar, and spiral ribs on the body whorl grading anteriorly from medium to fine rather than being differentiated into pairs or sets of three.

Genus *Turricula* Schumacher, 1817

TYPE SPECIES. *Turricula flammea* Schumacher, 1817, by monotypy; Recent, Sri Lanka.

Turricula sp., aff. *T. burroensis* (Nelson, 1925)

Figure 42

LOCAL OCCURRENCE. CSUN loc. 969.

REMARKS. A single specimen was found, and it is missing the upper part of the spire and about half

of the anterior canal. The specimen is also somewhat weathered, and the nodes on the spire are correspondingly subdued. The specimen has affinity to *Turricula burroensis* (Nelson, 1925) from the so-called "Martinez Marine Member" ("Martinez Stage") part of the Santa Susana Formation on the south side of Simi Valley. The specimen from CSUN locality 969 differs from *T. burroensis* (Nelson, 1925:435, pl. 60, figs. 8, 9) by having more spiral ribs (26 rather than 16) on the penultimate whorl and more spiral ribs (about 60 rather than 45) on the body whorl.

Nelson (1925) originally assigned his species to *Turris* Röding, 1798, but Zinsmeister (1983b) re-assigned the species to *Turricula* based on the diagnostic presence of the anal sinus on the shoulder slope.

Although *Turricula calafia* Nelson (1925:434, pl. 60, figs. 1a, 1b), known only from the same locality as *T. burroensis*, is similar to *T. burroensis*, the specimen of *Turricula* from CSUN locality 969 is more similar to *T. burroensis* in that it is slimmer.

Subclass Heterobranchia Gray, 1840

Order Heterostropha Fischer, 1885

Family Architectonicidae Gray, 1850

Genus *Architectonica* Röding, 1798

Type Species. *Trochus perspectivus* Linnaeus, 1758, by subsequent designation (Gray, 1847b); Recent, Indo-Pacific.

Subgenus *Architectonica* s.s.

Architectonica (*Architectonica*) *llajasensis*
Sutherland, 1966

Figures 43, 44

Architectonica llajasensis Sutherland, 1966:1-4, figs. 1, 2.

Architectonica (*Architectonica*) *llajasensis* Sutherland. Squires, 1984:19, fig. 6k; Squires and Demettrion, 1994:131-132, fig. 16.

Figures 38-56. Gastropods and bivalves from the upper 100 m of the Santa Susana Formation, Simi Valley. All specimens coated with ammonium chloride. 38-48. Gastropods. 38. *Brachysphingus mammilatus* Clark and Woodford, 1927, apertural view, $\times 1.4$, LACMIP hypotype 12685, CSUN loc. 958. 39, 40? *Ancillarina* sp., $\times 2.5$, LACMIP hypotype 12686, CSUN loc. 961. 39. Apertural view. 40. Abapertural view. 41. *Gemmula* sp., aff. *G. diabloensis* Clark and Woodford, 1927, apertural view, $\times 4.5$, LACMIP hypotype 12687, CSUN loc. 969. 42. *Turricula* sp., aff. *T. burroensis* (Nelson, 1925), abapertural view, $\times 2$, LACMIP hypotype 12688, CSUN loc. 961. 43, 44. *Architectonica* (*A.*) *llajasensis* Sutherland, 1966, $\times 2$, LACMIP hypotype 12689, LACMIP loc. 26609. 43. Apical view. 44. Umbilical view. 45, 46. *Ringicula* (*R.*) *pinguis* (Gabb, 1864), $\times 13.2$, LACMIP hypotype 12690, LACMIP loc. 1344. 45. Apertural view. 46. Right-lateral view. 47, 48. *Cylichnina tantilla* (Anderson and Hanna, 1925). 47. Apertural view, $\times 5.4$, LACMIP hypotype 12691, CSUN loc. 964. 48. Abapertural view, $\times 4.8$, LACMIP hypotype 12692, CSUN loc. 970. 49-54. Bivalves. 49. *Acila* (*Truncaila*) *decisa* (Conrad, 1855), latex peel of external mold, right valve, $\times 3.8$, LACMIP hypotype 12693, CSUN loc. 959. 50. *Nuculana* (*Saccella*) *gabbii* (Gabb, 1869), latex peel of external mold, left valve, $\times 6$, LACMIP hypotype 12694, CSUN loc. 967. 51. *Arca* (*A.*) *filewiczii* Squires, 1991a, left valve, $\times 1$, LACMIP holotype 8365, CSUN loc. 965. 52, 53. *Spondylus carlosensis* Anderson, 1905, $\times 2.1$, LACMIP hypotype 12695, CSUN loc. 1343. 52. Left (free) valve. 53. Right (attached) valve. 54-56. *Pycnodonte* (*Phygraea*) sp., aff. *Pycnodonte* (*Phygraea*) *pacifica* Squires and Demettrion, 1990, CSUN loc. 1343. 54. Left (lower) valve, $\times 1.4$, LACMIP hypotype 12696. 55, 56. Right (upper) valve, $\times 2.5$, LACMIP hypotype 12697. 55. Interior. 56. Exterior.

PRIMARY TYPE MATERIAL. LACMIP holotype 1140, LACMIP loc. 461-B, Llajas Formation, Simi Valley, California.

MOLLUSCAN STAGE RANGE. “Meganos” and “Domengine” (no specimens known from “Caypay Stage”).

GEOGRAPHIC DISTRIBUTION. Baja California Sur, Mexico, to Simi Valley, California.

LOCAL OCCURRENCE. CSUN locs. 966, 958.

REMARKS. A single specimen was found at CSUN locality 966, and this is the first record of *Architectonica* (*Architectonica*) *llajasensis* from “Meganos Stage” strata. An internal mold was found at CSUN locality 958.

Family Ringiculidae Philippi, 1853

Genus *Ringicula* Deshayes, 1838

Subgenus *Ringicula* s.s.

Type Species. *Auricula ringens* Lamarck, 1804b, by subsequent designation, Gray (1847b); Eocene, Paris Basin, France.

Ringicula (*Ringicula*) *pinguis* (Gabb, 1864)

Figures 45, 46

Cinulia pinguis Gabb, 1864:112, pl. 29, figs. 221a, 221b.

Ringinella pinguis Gabb, 1869:175; Dickerson, 1914:17, figs. 4a, 4b.

Tornatellaea pinguis (Gabb). Nelson, 1925:436, pl. 60, figs. 5, 6; Stewart, 1927:433–434, pl. 25, fig. 10; Schenck and Keen, 1940:pl. 20, fig. 11.

Tornatella pinguis (Gabb). Zinsmeister, 1983a:pl. 4, fig. 31.

PRIMARY TYPE MATERIAL. ANSP lectotype 4265, Martinez Formation, “in the bluffs, a mile west of Martinez” (Gabb, 1864), Contra Costa County, California.

MOLLUSCAN STAGE RANGE. “Martinez” to “Meganos.”

GEOGRAPHIC DISTRIBUTION. Southern California to Martinez, California.

LOCAL OCCURRENCE. CSUN loc. 1344.

REMARKS. Eight specimens were found, all early juveniles of minute size.

Ringicula s.s. is characterized by a small, low-spire globose to subglobose shape with a sculpture of spirally incised furrows, a greatly thickened outer lip, an internally dentate outer lip, a columella with two strong folds, and an anterior notch to the aperture (Sohl, 1964; Davies and Eames, 1971). The Santa Susana Formation specimens have all of these characteristics. Genus *Tornatellaea* Conrad, 1860, of family Acteonidae Orbigny, 1835, is similar to *Ringicula* s.s., but *Tornatellaea* lacks a varixlike outer lip and has no notch at the anterior end of the aperture.

The presence of *Ringicula* (*R.*) *pinguis* at CSUN loc. 1344 is the first record of this species in “Meganos Stage” strata.

Order Opisthobranchia Milne-Edwards, 1848

Family Cylichnidae A. Adams, 1854

Genus *Cylichnina* Monterosato, 1884

Type Species. *Bulla umbilicata* Montagu, 1803, by original designation; Recent, Norway.

Cylichnina tantilla (Anderson and Hanna, 1925)

Figures 47, 48

Cylichnella tantilla Anderson and Hanna, 1925: 140, pl. 7, figs. 4, 8, 9.

Cylichnina tantilla (Anderson and Hanna). Stewart, 1927:439–441, pl. 27, figs. 2–4; 1946:pl. 11, fig. 11; Turner, 1938:67–68, pl. 20, figs. 9, 10; Vokes, 1939:110, pl. 16, figs. 28, 33, 39; Weaver, 1943:548–549, pl. 100, figs. 10–12, 14–15; Squires, 1983a, fig. 9a; 1984:40, fig. 9p; 1988b: 17, fig. 43; 1991b:pl. 2, fig. 14; Squires et al., 1992:pl. 1, fig. 24; Squires and Demettrion, 1992: 34, fig. 94.

PRIMARY TYPE MATERIAL. CAS holotype 958, CAS paratypes 959 and 960, all from CAS locality 711, Tejon Formation, Grapevine Canyon, southern end of San Joaquin Valley, California.

MOLLUSCAN STAGE RANGE. “Meganos” through “Tejon.”

GEOGRAPHIC DISTRIBUTION. San Laguna Ignacio area, Baja California Sur, Mexico, to southwestern Washington.

LOCAL OCCURRENCE. CSUN locs. 961?, 964, 967, 970, 1344, 1346.

REMARKS. Specimens are rare and generally not well preserved. This is the first report of this species from “Meganos Stage” strata.

Class Bivalvia Linnaeus, 1758

Order Nuculoida Dall, 1889

Family Nuculidae Gray, 1824

Genus *Acila* H. Adams and A. Adams, 1858

Type Species. *Nucula divaricata* Hinds, 1843, by subsequent designation (Stoliczka, 1871); Miocene to Pliocene, Japan; Recent, Japan, China, and Korea.

Subgenus *Truncacila* Grant and Gale, 1931

Type Species. *Nucula castrensis* Hinds, 1843, by original designation; Pliocene to Pleistocene, California; Recent, northeastern Pacific.

Acila (*Truncacila*) *decisa* (Conrad, 1855)

Figure 49

Nucula decisa Conrad, 1855:11–12; 1857:pl. 3, fig. 19.

Acila gabbiana Dickerson, 1916:481, pl. 36, fig. 1; Anderson and Hanna, 1925:176, pl. 9, fig. 12.

Nucula (Acila) stillwaterensis Weaver and Palmer, 1922:6, pl. 8, fig. 8.

Acila lajollaensis Hanna, 1927:270, pl. 25, figs. 1, 3, 5, 7–8, 12, 15.

Acila (Truncacla) decisa (Conrad). Schenck, 1936: 53–56, pl. 3, figs. 1–9, 11–15; pl. 4, figs. 1–2; text fig. 7 (22, 23, 25); Turner, 1938:41–42, pl. 5, figs. 2–3; Vokes, 1939:41, pl. 1, figs. 7–8; Weaver, 1943:22–23, pl. 6, figs. 1, 4, 8; pl. 7, figs. 8–9; Moore, 1968:30, pl. 13a; 1983:A10, pl. 1, fig. 14; Givens, 1974:38, pl. 1, fig. 1; Squires, 1984:41, fig. 10a; 1987:54, fig. 86; 1988b:17, fig. 44; 1991b:pl. 2, fig. 15; Throckmorton, 1988:pl. 1, fig. 19; Squires and Goedert, 1997:fig. 2g.

PRIMARY TYPE MATERIAL. UCMP neotype 31132, designated by Schenck (1936), UCMP loc. 5062, Ardath Shale, San Diego County, California.

MOLLUSCAN STAGE RANGE. “Martinez” through upper Eocene (*Turritella schencki delaguerrae* Zone of Kleinpell and Weaver, 1963).

GEOGRAPHIC DISTRIBUTION. San Diego, California, to Kamchatka, Russia.

LOCAL OCCURRENCE. CSUN locs. 958, 959, 961.

REMARKS. Specimens are scarce to uncommon and are preserved as external molds. They are most abundant at locality 961, where six specimens were found. The Kamchatka occurrence of this species is in lower Eocene strata along the shore of the Penzhin Inlet (northern Sea of Okhotsk) and the nearby Koryak Uplands to the east (Devyatilova and Volobueva, 1981).

Family Nuculanidae H. Adams and A.
Adams, 1858

Genus *Nuculana* Link, 1807

Type Species. *Arca rostrata* Chemnitz, 1784, by original designation; Recent, North Atlantic.

Subgenus *Saccella* Woodring, 1925

TYPE SPECIES. *Arca fragilis* Chemnitz, 1784, by original designation; Recent, Mediterranean Sea.

Nuculana (Saccella) gabbii (Gabb, 1869)
Figure 50

Leda? protexta Conrad. Gabb, 1864:199 (in part), pl. 26, fig. 185.

Not *Leda? protexta* Gabb, 1860:303, pl. 48, fig. 23.

Nuculana gabbii Conrad, 1866:3, *nomen nudum*.
Leda gabbii (Conrad). Gabb, 1869:197.

Leda gabbii (Conrad). Stanton, 1896:1041, pl. 64, fig. 8; Arnold, 1907a:pl. 10, fig. 1; 1910:pl. 2, fig. 8; Arnold and Anderson, 1910:pl. 24, fig. 8; Waring, 1917:76, pl. 13, fig. 6; Dickerson, 1915: pl. 1, fig. 1; 1916:pl. 36, fig. 3; Clark, 1929:pl. 3, fig. 12; Clark and Woodford, 1927:85–86, pl. 14, fig. 2.

Leda vogdesi Anderson and Hanna, 1925:177–179, pl. 2, figs. 8, 9.

Saccella gabbii (Gabb). Stewart, 1930:55–58, pl. 7, fig. 3, pl. 10, fig. 4.

Nuculana (Saccella) gabbii (Gabb). Vokes, 1939: 41–42; Kleinpell and Weaver, 1963:195, pl. 28, fig. 1; Givens, 1974:39, pl. 1, fig. 3; Moore, 1983:A16, pl. 2, figs. 7, 8; Squires, 1984:41, fig. 10b.

Nuculana gabbii (Gabb). Deméré et al., 1979:pl. 1, fig. 13.

?*Nuculana (Calorhadia) gabbii* (Gabb). Zinsmeister, 1983a:pl. 1, fig. 3.

PRIMARY TYPE MATERIAL. ANSP lectotype ANSP 4476 (of *Leda gabbii* Gabb, 1869), designated by Stewart (1930), “Tejon Formation,” Martinez, California.

MOLLUSCAN STAGE RANGE. “Martinez” through upper Eocene (*Turritella schencki delaguerrae* Zone of Kleinpell and Weaver, 1963).

GEOGRAPHIC DISTRIBUTION. Simi Valley, California, to Kamchatka, Russia.

LOCAL OCCURRENCE. CSUN locs. 958, 960, 961, 967, 1342?

REMARKS. Only a few poorly preserved internal molds were found, except at CSUN locality 967 where a well-preserved external mold was found. The Kamchatka occurrence of this species is in lower Eocene strata along the shore of the northern Sea of Okhotsk (Devyatilova and Volobueva, 1981).

Order Arcoida Stoliczka, 1871

Family Arcidae Lamarck, 1809

Genus *Arca* Linnaeus, 1758

TYPE SPECIES. *Arca noae* Linnaeus, 1758, by subsequent designation (Schmidt, 1818); Recent, Mediterranean Sea and northwest Africa.

Subgenus *Arca* s.s.

Arca (Arca) filewiczii Squires, 1991a
Figure 51

Arca (Arca) filewiczii Squires, 1991a:68–69, figs. 2–6.

PRIMARY TYPE MATERIAL. LACMIP holotype 8365 and LACMIP paratype 8366; both from CSUN loc. 965, upper 100 m of the Santa Susana Formation, north side of Simi Valley, California.

MOLLUSCAN STAGE RANGE. “Meganos.”
GEOGRAPHIC DISTRIBUTION. North side of Simi Valley, California.

LOCAL OCCURRENCE. CSUN loc. 965

REMARKS. Two specimens were found; one is closed valved.

Family Spondylidae Gray, 1826

Genus *Spondylus* Linnaeus, 1758

Type Species. *Spondylus gaederopus* Linnaeus, 1758, by subsequent designation (Schmidt, 1818); Recent, Mediterranean Sea and northwest Africa.

Spondylus carlosensis Anderson, 1905

Figures 52, 53

Spondylus carlosensis Anderson, 1905:194, pl. 13, fig. 1; Arnold, 1910:pl. 2, figs. 6,7; Dickerson, 1915:pl. 1, fig. 7; Anderson and Hanna, 1925:189–190, text fig. 10; Vokes, 1939:57, pl. 3, figs. 10, 13; Kleinpell and Weaver, 1963:199, pl. 31, fig. 6; Squires, 1984:43, fig. 10j; Moore, 1987:C6–C7, pl. 1, fig. 5; Squires and Goedert, 1994:23, fig. 55.

Spondylus cf. *S. carlosensis* Anderson. Squires, 1991b: pl. 2, fig. 17.

PRIMARY TYPE MATERIAL. CAS holotype 56, west and north of Coalinga, NW 1/4 of section 35, T 20 S, R 14 E, Domengine Formation, Fresno County, California.

MOLLUSCAN STAGE RANGE. “Meganos” through middle part of “Tejon.”

GEOGRAPHIC RANGE. Simi Valley, California, to southwestern Washington.

LOCAL OCCURRENCE. CSUN loc. 1343.

REMARKS. Two specimens were found. One is small (height 20 mm), closed valved, and well-preserved overall. This specimen affords new morphologic information because, unlike previously described and illustrated specimens of this species, it shows both the left (Fig. 52) and right (Fig. 53) valves rather than only the left valve. The right (attached) valve is less circular and much more convex than the left. The radial ribs on the right valve are less closely spaced, wider, less sharp sided, and more spinose than those on the left. Usually, every fourth or fifth radial rib on both valves (especially on the right valve) is more prominent than the other ribs. Although the auricles are mostly missing on the right valve, those on the left valve are intact (a rare condition). The auricles on the left valve are small, and the anterior one has coarse growth lines and two strong and wide radial ribs, one of which delineates the hinge-line. The posterior auricle on the left valve is smooth, but it is set off from the rest of the valve by a moderately strong radial rib. On both valves, the beak is anterior of the valve center.

The other specimen of *Spondylus carlosensis* found at CSUN locality 1343 is a portion of a right valve attached to a specimen of the solitary coral ?*Antillophyllia californica* new species.

The presence of *Spondylus carlosensis* in the upper 100 m of the Santa Susana Formation is the first record of this species from “Meganos Stage” strata.

Order Ostreoida Férussac, 1822

Family Gryphaeidae Vyalov, 1936

Genus *Pycnodonte* Fischer de Waldheim, 1835

TYPE SPECIES. *Pycnodonte radiata* Fischer de Waldheim, 1835, by original designation; Late Cretaceous, Crimea.

Subgenus *Phygraea* Vyalov, 1936

TYPE SPECIES. *Gryphaea* (*Gryphaea*) sec. *Phygraea frauscheri* Vyalov, 1936, by original designation; late Paleocene, Austria.

Pycnodonte (*Phygraea*) sp., aff. *Pycnodonte* (*Phygraea*) *pacifica* Squires and Demettrion, 1990

Figures 54–56

LOCAL OCCURRENCE. CSUN loc. 1343.

REMARKS. A single left (lower valve) was found, and 13 right (upper) valves were found. The left valve is weathered, missing some shell material, probably not complete, and infilled with very hard matrix. It is smooth, very convex, and has a prominent winglike extension separated from the main part of the valve by a moderately shallow sulcus that deepens ventrally. Only one of the right valves is mostly complete. It is smooth, flattish, has vermicular anachomata, and has a prominent winglike extension bearing a finely granular appearance because of vesicular shell structure. In addition, there is a prominent ridge interiorly where the right valve joins the left valve. The specimens have affinity with *Pycnodonte* (*Phygraea*) *pacifica* Squires and Demettrion, 1990, from the “Capay Stage” through the lower middle part of the “Tejon Stage” within the Bateque Formation in Baja California Sur, Mexico. The Santa Susana Formation specimens differ from *Pycnodonte* (*Phygraea*) *pacifica* Squires and Demettrion (1990:386, fig. 3.1–3.4) by having a smaller size, more prominent anachomata, and, apparently, a radial sulcus that originates farther from the umbo. These differences, however, might be related to growth stage. It is possible that all the Santa Susana Formation specimens are juveniles. All known specimens of *Pycnodonte* (*Phygraea*) *pacifica* are adults. Until more Santa Susana Formation specimens (especially of the left valve) are found, it cannot be positively determined if the already-collected material represents a new species or whether it represents only the juvenile stage of *Pycnodonte* (*Phygraea*) *pacifica*.

The only other species of *Pycnodonte* (*Phygraea*) known from the Paleogene rock record of the Pacific coast of North America is *P. (P.) cuarentaensis* Squires and Demettrion, 1994, from the “Capay Stage” part of the Bateque Formation in Baja California Sur, Mexico. *Pycnodonte* (*Phygraea*) *cuarentaensis* Squires and Demettrion (1994:132–133, figs. 17–22) differs from both *Pycnodonte* (*Phygraea*) *pacifica* and the Santa Susana Formation specimens by having fine radial ribbing on the left valve.

The specimens of *Pycnodonte* (*Phygraea*) sp., aff. *Pycnodonte* (*Phygraea*) *pacifica* in the upper 100 m of the Santa Susana Formation in Simi Valley represent the earliest occurrence of *Phygraea* on the Pacific coast of North America, and its first occur-

rence on the Pacific coast of North America outside of Baja California Sur, Mexico.

Order Veneroida H. Adams and A. Adams,
1856

Family Fimbriidae Nicol, 1950

Genus *Fimbria* Megerle von Mühlfeld, 1811

TYPE SPECIES. *Fimbria magna* Megerle von Mühlfeld, 1811 [= *Venus fimbriata* Linnaeus, 1758], by original designation; Recent, Indo-Pacific.

Fimbria susanensis Squires, 1990

Figure 57

Fimbria susanensis Squires, 1990:554, fig. 2.1–2.3.

PRIMARY TYPE MATERIAL. UCMP holotype 38568 from UCMP loc. 7009; UCMP paratype 38569 from UCMP loc. 3792. Both specimens from the upper 100 m of the Santa Susana Formation, south side of Simi Valley, California.

MOLLUSCAN STAGE RANGE. “Meganos.”

GEOGRAPHIC RANGE. South side Simi Valley, California.

LOCAL OCCURRENCE. CSUN loc. 1342 and UCMP loc. 7009.

REMARKS. Seven specimens were found, and a few show the hinge. *Fimbria susanensis* has been reported from UCMP localities 3792 and 7009, but, as mentioned under *Velates perversus*, the exact location of UCMP locality 3792 is not known.

Squires (1990) incorrectly equated CSUN locality 1342 with UCMP loc. 3791. The latter locality, which is in close proximity to CSUN locality 1342, actually is the same as CSUN locality 1343.

Fimbria susanensis is the earliest occurrence of *Fimbria* in North America (Squires, 1990).

Family Carditidae Fleming, 1828

Genus *Venericardia* Lamarck, 1801

TYPE SPECIES. *Venericardia imbricata* Lamarck, 1801 [= *Venericardia imbricata* Gmelin, 1791], by subsequent designation (Schmidt, 1818); Eocene, Paris Basin France.

Subgenus *Pacificor* Verastegui, 1953

TYPE SPECIES. *Venericardia mulleri* Verastegui, 1953, by original designation; Paleocene, California.

Venericardia (Pacificor) calafia susanaensis
Verastegui, 1953

Figure 58

Venericardia (Pacificor) susanaensis Verastegui, 1953:22–23, pl. 5, figs. 1–4.

Venericardia (Pacificor) hornii susanaensis Verastegui, Saul, 1983:pl. 1, fig. 14.

Venericardia (Pacificor) calafia susanaensis Verastegui, 1953:22–23, pl. 5, figs. 1–4.

tegui. Moore, 1992:E19–E20, pl. 1, figs. 14, 16–18.

PRIMARY TYPE MATERIAL. CAS holotype 8004, “Santa Susana shale,” McCray Oil Wells, Oil Canyon, north side of Simi Valley (exact locality unknown), California.

MOLLUSCAN STAGE RANGE. “Meganos.”

GEOGRAPHIC DISTRIBUTION. North side of Simi Valley, California.

LOCAL OCCURRENCE. CSUN locs. 959, 967.

REMARKS. Only a few fragments were found at localities 959 and 967. Elsewhere, in the northeast corner of section 31, T 3 N, R 17 W, a few meters below the base of the Lajas Formation, I found an internal mold of a closed-valved specimen. No other megafossils were found with this internal mold. In addition, new housing construction in the southwest corner of section 32, T 3 N, R 17 W uncovered a nearly complete, closed-valved specimen of this bivalve (James Rohrer, Petras Company, personal communication), which I was able to inspect and identify.

The holotype of *Venericardia (P.) calafia susanaensis* is incomplete. The exact location of its type locality is not known, but it is most likely in the upper 100 m of the Santa Susana Formation based on the recent discovery of this subspecies in this part of the formation (see above). The locality of the specimen illustrated by Saul (1983:pl. 1, fig. 14) is UCMP locality 7000, and the exact location of this locality, which is 7.5 m below the Lajas Formation according to Saul (1983), is also not known. Locality 7000 is also where the only specimens of *Turritella meganosensis* known from the upper Santa Susana Formation have been found.

Family Cardiidae Lamarck, 1809

Genus *Nemocardium* Meek, 1876

TYPE SPECIES. *Cardium semiasperum* Deshayes, 1858, by subsequent designation (Sacco, 1899); Eocene, Paris Basin, France.

Nemocardium linteum (Conrad, 1855)

Figure 59

Cardium linteum Conrad, 1855:3, 9; 1857:pl. 2, fig. 1; Anderson and Hanna, 1925:166–167, pl. 3, fig. 3.

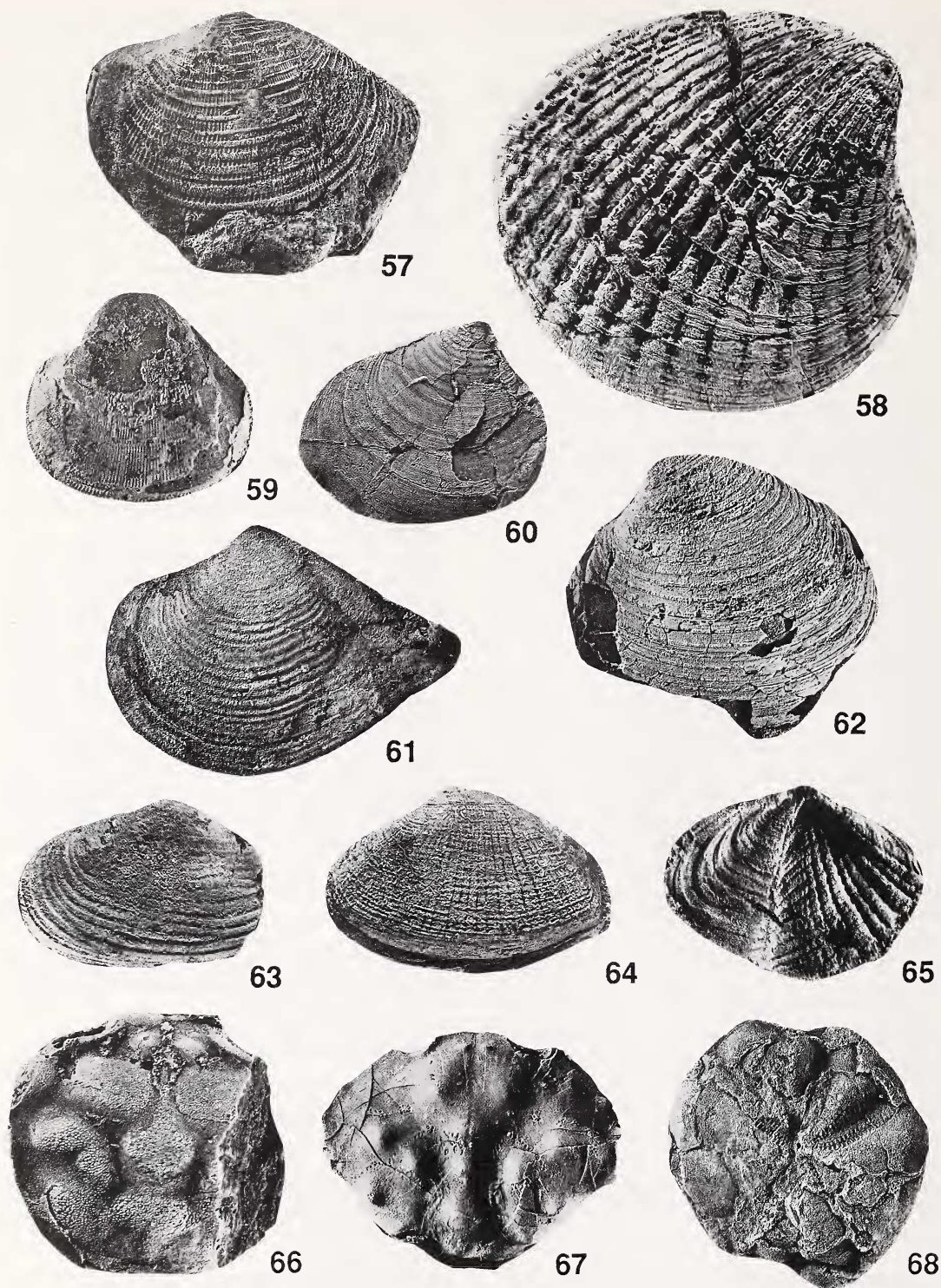
Cardium cooperii Gabb, 1864:172, pl. 24, figs. 154–154a; Arnold, 1907b:pl. 38, figs. 2–2a; Waring, 1917:pl. 13, fig. 3; Hanna, 1927:285, pl. 41, figs. 6, 7.

Cardium dalli Dickerson, 1913:289, pl. 14, fig. 4a–c.

Not *Cardium dalli* Heilprin, 1887:131, pl. 16a, fig. 70.

Cardium marysvillensis Dickerson, 1916:482 [new name for *Cardium dalli* Dickerson, 1913, preoccupied].

Cardium (Protocardium) marysvillensis Dickerson, Clark and Woodford, 1927:94, pl. 15, fig. 12.



Figures 57–68. Bivalves, crabs, and spatangoid echinoid from the upper 100 m of the Santa Susana Formation, Simi Valley. All specimens coated with ammonium chloride. 57–65. Bivalves. 57. *Fimbria susanensis* Squires, 1990, left valve, $\times 1$, UCMP holotype 38568, UCMP loc. 7009. 58. *Venericardia (Pacifcor) calafia susanensis* Verastegui, 1953, right valve, $\times 0.8$, UCMP hypotype 37431, UCMP loc. 7009. 59. *Nemocardium linteum* (Conrad, 1855), ? right valve, $\times 2.4$, LACMIP hypotype 12698, LACMIP loc. 26611 [= CSUN loc. 965]. 60. *Saulella undulifera* (Gabb, 1869), latex peel of external mold, right valve, $\times 2.1$, LACMIP hypotype 12699, LACMIP loc. 26610 [= CSUN loc. 967]. 61. *Macoma rosa* Hanna, 1927, internal mold, left valve, $\times 3.6$, LACMIP hypotype 12700, CSUN loc. 1342. 62. *Pitar uvasana coquillensis* Turner, 1938, left valve, $\times 2.4$, LACMIP hypotype 12701, CSUN loc. 1344. 63. *Corbula (Caryocorbula) dickersoni*

Nemocardium linteum (Conrad). Stewart, 1930: 275–277, pl. 8, fig. 6; Turner, 1938:52, pl.10, fig. 10; Vokes, 1939:76–77, pl. 11, figs. 6, 9; Weaver, 1943:159–160, pl. 38, fig. 3; 1953:28; Stewart, 1946:pl. 11, fig. 19; Moore, 1968:30, pl. 13, fig. d; Zinsmeister, 1983a:pl. 2, fig. 7; Squires, 1984: 49–50, fig. 12c; 1987:65, 67, fig. 113; 1988b:19, fig. 51; Squires et al., 1992:pl. 1, fig. 33; Squires and Demetrio, 1992:42, fig. 121.

Cardium (*Nemocardium*) *lintheum* Conrad. Kleinpell and Weaver, 1963:202, pl. 34, fig. 4.

PRIMARY TYPE MATERIAL. USNM holotype 1834, Domingine Formation near Martinez, California.

ILLUSTRATED SPECIMEN. LACMIP hypotype 12248.

MOLLUSCAN STAGE RANGE. “Martinez” through “Tejon.”

GEOGRAPHIC RANGE. Eastern Laguna San Ignacio area, Baja California Sur, Mexico, to Pulali Point, Jefferson County, Washington.

LOCAL OCCURRENCE. CSUN locs. 965, 1553, 1553a, 1554, 1555.

REMARKS. Specimens are uncommon at CSUN locality 1553 and rare at the other localities.

Family Tellinidae Blainville, 1814

Genus *Saulella* Zinsmeister, 1983b

TYPE SPECIES. *Tellina undulifera* Gabb, 1869, by original designation; Paleocene, California.

Saulella undulifera (Gabb, 1869)

Figure 60

Tellina undulifera Gabb, 1869:183, pl. 3, fig. 74; Dickerson, 1914:pl. 11, fig. 7a–7c.

“*Tellina*?” *undulifera* Gabb. Stewart, 1930:204–205, pl. 7, fig. 8; Nelson, 1925:415, pl. 53, fig. 8a, 8b.

Saulella undulifera (Gabb). Zinsmeister, 1983b: 1288, fig. 11, J.

PRIMARY TYPE MATERIAL. ANSP holotype 4551, from just “west of Martinez,” California.

MOLLUSCAN STAGE RANGE. “Martinez” and “Meganos.”

GEOGRAPHIC DISTRIBUTION. Northern Baja California, Mexico, to northern California.

LOCAL OCCURRENCE. CSUN loc. 967.

REMARKS. Two small specimens (up to 17 mm in height) were found, and both are external molds. They represent the first occurrence of this species

in “Meganos Stage” strata. *Saulella undulifera* has long been used as a guide fossil of the Paleocene of the Pacific coast of North America and is common throughout the “Martinez Stage” in California (Nelson, 1925).

Genus *Macoma* Leach, 1819

TYPE SPECIES. *Macoma tenera* Leach, 1819 [= *Tellina calcarea* Gmelin, 1791], by monotypy; Recent, Arctic.

Macoma rosa Hanna, 1927

Figure 61

Macoma rosa Hanna, 1927:292, pl. 41, figs. 2–5, 8; Clark, 1929:pl. 6, fig. 15; Squires, 1984:50, fig. 12e.

PRIMARY TYPE MATERIAL. UCMP holotype 31094, Ardath Shale, UCMP loc. 3993; UCMP paratype 31095, UCMP loc. 5089; UCMP paratypes 31096–31097, UCMP loc. 5085; all from the Ardath Shale, San Diego County, California.

MOLLUSCAN STAGE RANGE. “Meganos” and “Domengine” (no specimens known from “Capay Stage”).

GEOGRAPHIC DISTRIBUTION. San Diego to Simi Valley, California.

LOCAL OCCURRENCE. CSUN loc. 1342.

REMARKS. A single internal mold was found, and this specimen represents the first occurrence of this species in “Meganos Stage” strata.

Family Veneridae Rafinesque, 1815

Genus *Pitar* Römer, 1857

TYPE SPECIES. *Venus tumens* Gmelin, 1791, by monotypy; Recent, West Africa.

Pitar uvasana coquillensis Turner, 1938

Figure 62

Pitar uvasana coquillensis Turner, 1938:54, pl. 11, figs. 14–17.

PRIMARY TYPE MATERIAL. UCMP holotype 33076, UCMP loc. A-836; UCMP paratypes 33077–33078, UCMP loc. A-838; all from Middle Fork Coquille River, Coos County, Oregon.

MOLLUSCAN STAGE RANGE. “Meganos” and “Capay.”

GEOGRAPHIC DISTRIBUTION. Simi Valley, California, to Middle Fork Coquille River, Coos County, Oregon.

←

Weaver and Palmer, 1922, left valve, $\times 4.5$, LACMIP hypotype 12702, CSUN loc. 1344. 64. *Corbula* (*Caryocorbula*) *parilis* Gabb, 1864, left valve, $\times 4.4$, LACMIP hypotype 12703, CSUN loc. 958. 65. *Netastoma squiresi* Kennedy, 1993, external (concave) mold of left valve, specimen lighted to give the effect of being a convex right valve, $\times 3.8$, LACMIP holotype 8405, CSUN loc. 967. 66, 67. Crabs. 66. *Cyclocorystes alderoni* Squires, 1980, dorsal view, $\times 4$, LACMIP hypotype 12704, CSUN loc. 965. 67. *Zanthopsis* sp., aff. *Z. hendersoni* Rathbun, 1926, dorsal view, $\times 1.1$, LACMIP hypotype 12705, CSUN loc. 958. 68. Spatangoid echinoid. *Schizaster diabloensis* Kew, 1920, crushed internal mold, aboral view, $\times 1.9$, LACMIP hypotype 12706, LACMIP loc. 26610 [= CSUN loc. 967].

LOCAL OCCURRENCE. CSUN locs. 1344, 1346, 1348.

REMARKS. Specimens are rare to common and most common at CSUN locality 1344. All specimens are single valves and are mostly poorly preserved due to weathering. These specimens represent the first occurrence of this species in "Meganos Stage" strata and its first occurrence outside of southwestern Oregon.

Order Myoida Stoliczka, 1870

Family Corbulidae Lamarck, 1818

Genus *Corbula* Bruguière, 1797

TYPE SPECIES. *Corbula sulcata* Lamarck, 1801, by subsequent designation (Schmidt, 1818); Recent, West Africa.

Subgenus *Caryocorbula* Gardner, 1926

TYPE SPECIES. *Corbula alabamiensis* Lea, 1833, by original designation; Eocene, Alabama.

Corbula (*Caryocorbula*) *dickersoni* Weaver and Palmer, 1922

Figure 63

Corbula dickersoni Weaver and Palmer, 1922:24–25, pl. 9, figs. 9–10; Clark, 1938:700, pl. 1, fig. 17; Weaver, 1943:257–258, pl. 61, figs. 13, 16–17, 20; Deméré et al., 1979:pl. 2, fig. 11.

Corbula (*Caryocorbula*) *dickersoni* Weaver and Palmer. Vokes, 1939:98, pl. 16, figs. 1, 5, 9. Givens, 1974:57, pl. 4, fig. 7. Squires, 1984:53, fig. 12m; 1987:70–71, fig. 124.

PRIMARY TYPE MATERIAL. CAS holotype 7452, CAS paratypes 7452A–B, both from UW loc. 329, Cowlitz Formation, Lewis County, Washington.

ILLUSTRATED SPECIMEN. LACMIP holotype 12249.

MOLLUSCAN STAGE RANGE. "Meganos" through "Tejon."

GEOGRAPHIC RANGE. San Diego, California, to Little River area, Grays Harbor County, Washington.

LOCAL OCCURRENCE. CSUN loc. 1344.

REMARKS. A single specimen was found, and it represents the first occurrence of this species in "Meganos Stage" strata.

Corbula (*Caryocorbula*) *parilis* Gabb, 1864

Figure 64

Corbula parilis Gabb, 1864:150, pl. 29, figs. 239, 239a; Arnold, 1910:106, pl. 2, fig. 2; Dickerson, 1915:84, pl. 4, fig. 8; 1916:pl. 40, fig. 10; Hanna, 1927:295, pl. 43, figs. 7–11, 13; Stewart, 1930:288–289, pl. 3, fig. 5; 1946:pl. 11, figs. 9, 10; Turner, 1938:65–66, pl. 8, figs. 11–14; Weaver, 1943:256, pl. 59, fig. 16.

Corbula (*Caryocorbula*) *parilis* Gabb. Vokes, 1939:

99, pl. 16, figs. 2–3, 6–7, 10; Givens, 1974:57, pl. 4, fig. 9; Squires, 1987:71, fig. 125.

PRIMARY TYPE MATERIAL. UCMP holotype 33151, Eocene strata, Martinez, California.

MOLLUSCAN STAGE RANGE. "Meganos" through "Transition."

GEOGRAPHIC DISTRIBUTION. San Diego, California, to southwestern Oregon.

LOCAL OCCURRENCE. CSUN locs. 958, 967.

REMARKS. Specimens are rare and are well-preserved single valves. These specimens represent the first occurrence of this species in "Meganos Stage" strata.

Family Pholadidae Lamarck, 1809

Genus *Netastoma* Carpenter, 1864

TYPE SPECIES. *Pholas darwinii* Sowerby, 1849, by monotypy; Recent, southeastern Pacific.

Netastoma squiresi Kennedy, 1993

Figure 65

Netastoma squiresi Kennedy, 1993:400, 402, fig. 2.9, 2.10.

PRIMARY TYPE MATERIAL. LACMIP holotype 8405, CSUN loc. 967, upper 100 m of the Santa Susana Formation, north side of Simi Valley, California.

MOLLUSCAN STAGE RANGE. "Meganos."

GEOGRAPHIC DISTRIBUTION. North side of Simi Valley, California.

LOCAL OCCURRENCE. CSUN loc. 967.

REMARKS. Only the holotype is known for this species. It is an external mold of a juvenile left valve. *Netastoma squiresi* is the oldest known representative of the genus, whose geologic range was previously known as Pliocene to Recent (Kennedy, 1993).

Phylum Arthropoda Siebold and Stannius, 1848

Class Malacostraca Latreille, 1806

Order Decapoda Latreille, 1803

Family Xanthidae MacLeay, 1838

Genus *Cyclocorystes* Bell, 1858

TYPE SPECIES. *Cyclocorystes pulchellus* Bell, 1858, by original designation; early Eocene, England.

Cyclocorystes aldersoni Squires, 1980

Figure 66

Cyclocorystes aldersoni Squires, 1980:474–475, figs. 2, 3.

PRIMARY TYPE MATERIAL. LACMIP holotype 5893; LACMIP paratypes 5864–5866; all from CSUN loc. 354, upper Santa Susana Forma-

tion, east-central Santa Monica Mountains, California.

MOLLUSCAN STAGE RANGE. “Martinez” and “Meganos.”

GEOGRAPHIC DISTRIBUTION. Garapito Creek, east-central Santa Monica Mountains, Los Angeles County, and south side of Simi Valley; both in southern California.

LOCAL OCCURRENCE. CSUN locs. 965, 966.

REMARKS. Specimens are rare, moderately well preserved, and missing their legs. These specimens represent the first occurrence of this species in “Meganos Stage” strata and its first occurrence outside of the Santa Monica Mountains.

Genus *Zanthopsis* M’Coy, 1849

TYPE SPECIES. *Cancer leachii* Desmarest, 1822, by original designation; early Eocene, England.

Zanthopsis sp., aff. *Z. hendersoni* Rathbun, 1926

Figure 67

LOCAL OCCURRENCE. CSUN loc. 958.

REMARKS. Two internal molds were found. They show close affinity with *Zanthopsis hendersoni* Rathbun, 1926, from Oligocene rocks in Oregon and from the upper part of the Santa Susana Formation on the north side of Simi Valley. The exact location of the type locality of *Z. hendersoni* is not known, but it is near Eugene in Lane County, Oregon. The specimens from CSUN locality 958 differ from *Z. hendersoni* Rathbun (1926: 53–54, pl. 10, figs. 5, 6) by having a frontal region that is much less produced and not dentate and by having a tubercle on each of the protogastric areas. The frontal region on specimens from CSUN locality 958 is essentially straight and without teeth. It is possible that the material from the upper part of the Santa Susana Formation represents a new species. More specimens of *Z. hendersoni* are needed to determine the full range of morphologic variability of this species. Only then will it be possible to decide if the specimens of *Z. sp.*, aff. *Z. hendersoni* represent a new species.

The geologic range of genus *Zanthopsis* is Paleocene to Oligocene, with distribution in Europe, West Africa, West Indies, Panama, and North America (Glaessner, 1969).

Phylum Echinodermata Klein, 1734

Class Echinoidea Leske, 1778

Order Spatangoida Claus, 1876

Family Schizasteridae Lambert, 1905

Genus *Schizaster* Agassiz, 1836

TYPE SPECIES. *Schizaster studeri* Agassiz, 1836, by subsequent designation (ICZN, 1948:523–529, opin. 209); late Eocene, Italy and southern France.

Schizaster diabloensis Kew, 1920

Figure 68

Schizaster diabloensis Kew, 1920:150–151, pl. 41, fig. 5a–c; Clark and Woodford, 1927:123, pl. 22, fig. 14; Clark, 1929:pl. 4, fig. 13; Squires, 1984: 56, fig. 13d; 1994:pl. 3, fig. 8.

PRIMARY TYPE MATERIAL. UCMP holotype 11387, UCMP loc. 1427, Eocene strata, south side of Mount Diablo, California.

MOLLUSCAN STAGE RANGE. “Meganos” through middle part of “Tejon.”

GEOGRAPHIC DISTRIBUTION. Simi Valley, California, through Marysville Buttes, California.

LOCAL OCCURRENCE. LACMIP loc. 26610.

REMARKS. Three specimens were found. Two are badly crushed internal molds. The other specimen (Fig. 68) is a partial external mold.

Clark and Woodford (1927) and Clark (1929) reported *Schizaster diabloensis* as occurring in the “Meganos horizon” at various places throughout California, including Simi Valley, but they provided few stratigraphic details. The specimens from LACMIP locality 26610 confirm the presence of this species in “Meganos Stage” strata. Squires (1994) recently reported the youngest occurrence of *S. diabloensis* to be in the Coldwater Sandstone (middle part of the “Tejon Stage”) in upper Sespe Creek, Ventura County, California.

LOCALITIES

All base maps are U.S. Geological Survey, 7.5-minute (unless otherwise stated), topographic quadrangles.

CAS LOCALITIES

711. “On the east side of Grapevine Canyon near the point where the stream flows out upon the valley floor” (Anderson and Hanna, 1925:39). Grapevine quadrangle, Kern County, California.

30667. At elevation 800 m along crest of ridge on north side of Media Agua Creek, 442 m north and 183 m east of SW corner of section 27, T 28 S, R 19 E, La Yeguas Ranch quadrangle, 1959, Kern County, south-central California.

CSUN LOCALITIES

NORTH SIDE OF SIMI VALLEY

All are in the upper 100 m of the Santa Susana Formation (“Meganos Stage”) and, unless otherwise stated, in the Santa Susana quadrangle, 1951 (photorevised 1969), Ventura County, southern California. See Fig. 2 for stratigraphic position relative to the base and top of the upper 100 m of the Santa Susana Formation.

354. East bank of the south fork of Garapito Creek, 518 m S20°E from the intersection of the San Bernardino baseline and Los Angeles City boundary, Topanga quadrangle, 1952, Los Angeles County, southern California. Collected by R. Squires, 1979.

958. Bulldozer-generated exposure now under houses, at elevation of 346 m, just west of intersection of Chumash Street and Indian Hills Drive, 381 m south and 107

m east of section 5, T 2 N, R 17 W. Collected by R.L. Squires, Aug. 19, 1984.

959. At elevation of 347 m, 373 m east and 55 m south of NW corner of section 5, T 2 N, R 17 W. Collected by R.L. Squires, Aug. 24, 1984.

960. At elevation of 390 m, on south bank of Las Lajas Canyon, 594 m east and 579 m north of SW corner of section 32, T 3 N, R 17 W. Collected by R.L. Squires, Aug. 24, 1984, and Feb. 28, 1986.

961. At elevation of 376 m, on north bank of Las Lajas Canyon, 693 m east and 739 m north of SW corner of section 32, T 3 N, R 17 W. Collected by R.L. Squires, Aug. 24, 1984.

962. At elevation of 451 m, on east side of dirt road, 756 m east and 411 m south of NW corner of section 32, T 3 N, R 17 W. Collected by R.L. Squires, February 28, 1986.

963. At elevation of 483 m, 735 m east and 305 m south of NW corner of section 32, T 3 N, R 17 W. Collected by R.L. Squires, February 28, 1986.

964. [= LACMIP 21551]. At elevation of 509 m, in middle of dirt road, 792 m east and 171 m south of NW corner of section 32, T 3 N, R 17 W. Collected by R.L. Squires, February 28, 1986.

965. [= LACMIP 16111]. At elevation of 527 m, on east side of dirt road, 792 m east and 94 m south of NW corner of section 32, T 3 N, R 17 W. Collected by R.L. Squires, Feb. 28, 1986.

966. [= LACMIP 16893 and LACMIP 26609]. At elevation of 529 m, on east side of dirt road, 792 m east and 152 m south of NW corner of section 32, T 3 N, R 17 W. Collected by R.L. Squires, February 28, 1986.

967. [= LACMIP 12648 and LACMIP 26610]. At elevation of 533 m, just east of dirt road and on northeast side of small hill, 762 m east and 183 m north of SW corner of section 29, T 3 N, R 17 W. Collected by H. Seiden, 1951, and R.L. Squires, Feb. 28, 1986.

968. At elevation of 427 m, 457 m east and 308 m south of NW corner of section 32, T 3 N, R 17 W. This locality is about 3 m stratigraphically below base of Lajas Formation. Collected by R.L. Squires, Feb. 28, 1986.

969. [= LACMIP 16894]. At elevation of 381 m, on east side of Chivo Canyon, 343 m west and 107 m north of SE corner of section 30, T 3 N, R 17 W. Collected by R.L. Squires, March 1, 1986.

970. At elevation of 415 m, on north side of small tributary of east side of Chivo Canyon, 119 m west and 122 m north of SE corner of section 30, T 3 N, R 17 W. Collected by R.L. Squires, March 1, 1986.

971. At elevation of 401 m, on north side of small tributary of east side of Chivo Canyon, 21 m west and 107 m north of SE corner of section 30, T 3 N, R 17 W. Collected by R.L. Squires, March 1, 1986.

972. At elevation of 407 m, on north side of small tributary of east side of Chivo Canyon, 30 m west and 119 m north of SE corner of section 30, T 3 N, R 17 W. Collected by R.L. Squires, March 1, 1986.

973. [= LACMIP 16895]. At elevation of 412 m, near head of small tributary of east side of Chivo Canyon, 31 m west and 122 m north of SE corner of section 30, T 3 N, R 17 W.

SOUTH SIDE OF SIMI VALLEY

All are in the upper 100 m of the Santa Susana Formation ("Meganos Stage") and, unless otherwise stated, in the Calabasas quadrangle, 1952 (photorevised 1967), Ventura County, southern California.

1342. Top of hill at elevation of 431 m, 38 m west and 762 m north of SE corner of section 22, T 2 N, R 18 W. Collected by R.L. Squires, Aug. 14, 1989. This locality is in close proximity to CSUN loc. 1343 and 3 m stratigraphically below it.

1343. [= UCMP 3791]. On east side of hill at elevation of 427 m, 23 m west and 785 m north of SE corner of section 22, T 2 N, R 18 W. Collected by R.L. Squires, Aug. 14, 1989. This locality is in close proximity to CSUN loc. 1342 and 3 m stratigraphically above it.

1344. In saddle at elevation of 419 m, 183 m west and 823 m north of SE corner of section 22, T 2 N, R 18 W. Collected by R.L. Squires, Aug. 14, 1989.

1345. On west side of Runkle Canyon, at elevation of 355 m, 664 m east and 168 m south of NW corner of section 22, T 2 N, R 18 W. Collected by R.L. Squires, Aug. 16, 1989.

1346. On west side of Runkle Canyon, at elevation of 335 m, 739 m east and 148 m south of NW corner of section 22, T 2 N, R 18 W. Collected by R.L. Squires, Aug. 16, 1989.

1347. On west side of Runkle Canyon, at elevation of 353 m, 655 m east and 125 m south of NW corner of section 22, T 2 N, R 18 W. Collected by R.L. Squires, Aug. 16, 1989.

1348. On west side of Runkle Canyon, at elevation of 325 m, 777 m east and 61 m south of NW corner of section 22, T 2 N, R 18 W. Collected by R.L. Squires, Aug. 16, 1989.

1349. On east side of Runkle Canyon, at elevation of 317 m, 579 m west and 1579 m south of NE corner of section 14, T 2 N, R 18 W. Collected by R.L. Squires, Aug. 16, 1989.

1565. At elevation of 340 m, along west side of Bus Canyon, on north bank of an unnamed tributary that enters Bus Canyon from the west, 274 m south and 503 m west of NE corner of section 28, T 2 N, R 18 W, Thousand Oaks quadrangle, 1950 (photorevised 1967), Ventura County, southern California. Collected by A.J. Marro, 1985.

LACMIP LOCALITIES

461-B. On the northern slope of a small canyon intersecting Las Lajas Canyon from the east, Santa Susana quadrangle, 1959 (photorevised 1961), Ventura County, southern California. Collected by J.A. Sutherland, circa early 1960s. This locality is 61 m (200 ft.) from the top of the Lajas Formation.

7124. At elevation of 343 m, 610 m S45°W of 1480 ft. hill, SW 1/4 of section 13, T 2 N, R 18 W, Calabasas quadrangle, 1952 (photorevised 1967), Ventura County, southern California. Collected by W.P. Popenoe and M. Sperling, July 4, 1929.

12648. See CSUN 967.

21551. See CSUN 964.

23173. [Exact stratigraphic position not known.] About 15 m downslope from top of east-west trending ridge, southwest of Runkle Canyon, approximately 884 m north and 427 m west of SE corner of section 27, T 2 N, R 18 W, Calabasas quadrangle, 1952 (photorevised 1967), Ventura County, southern California. Collected by J.H. Fantozzi, Oct. 3, 1953.

26609. See CSUN 966.

26610. See CSUN 967.

26111. See CSUN 965.

26615. At elevation of 466 m, 518 m east of NW corner of section 32, on section line between sections 29 and 32,

T 3 N, R 17 W, Santa Susana quadrangle, 1959 (photo-revised 1961), Ventura County, southern California. Collected by H. Seiden, 1952.

UCMP LOCALITIES

672. South portion of crest of Parson's Peak, SE 1/4 of the NW 1/4 of section 24, T 18 S, R 14 E, Coalinga quadrangle, Fresno County, California.

1427. SW 1/4 of section 11, northeast of Wall Point, south side of Mount Diablo, northern California.

3157. On ridge top on north side of Deer Valley, 792 m south and 411 m west of NE corner of section 20, T 1 N, R 2 E, Antioch South quadrangle, 1980, Contra Costa County, northern California. Margaret Hamilton Sand [= division D of Meganos Formation as used by Clark and Woodford (1927)]. Collected by B.L. Clark and A.O. Woodford, circa 1923.

3159. On same ridge top as UCMP loc. 3157, 1036 m south and 46 m west of NE corner of section 20, T 1 N, R 2 E, Antioch South quadrangle, 1980, Contra Costa County, northern California. Margaret Hamilton Sand [= division D of Meganos Formation as used by Clark and Woodford (1927)]. Collected by B.L. Clark and A.O. Woodford, circa 1923.

3577. On ridge top 3399 m north and 610 m east of SW corner of Brentwood quadrangle, 1978, Contra Costa County, northern California. Margaret Hamilton Sand [= division D of Meganos Formation as used by Clark and Woodford (1927)]. Collected by B.L. Clark and A.O. Woodford, circa 1923.

3791. [see CSUN 1343]. Collected by R.N. Nelson, circa early 1920s.

3792. [Exact stratigraphic position not known]. West of Runkle Canyon on same ridge as UCMP loc. 3791, NE 1/4 SE 1/4 of section 22, T 2 N, R 18 W, Calabasas quadrangle, 1952 (photorevised 1967), Ventura County, southern California. Collected by R.N. Nelson, circa early 1920s.

3796. [Exact stratigraphic position not known]. On ridge at elevation of 640 m, 1524 m N68°W of 2150 ft. hill, south 1/2, NE 1/4 of section 27, T 2 N, R 18 W, Calabasas quadrangle, 1952 (photorevised 1967), Ventura County, southern California. Collected by R.N. Nelson, circa early 1920s.

3993. In bottom of Rose Creek where creek makes a strong bend to west, .3 km (.2 mi.) south of Bench Mark 176, 3.2 km east of La Jolla, La Jolla quadrangle, San Diego County, California.

5062. In sea cliff south of mouth of Soledad Valley, due west of midpoint between "P" and "u" of "Pueblo," La Jolla quadrangle, San Diego County, California.

5085. 2.62 inches north of the top of the "S" of "Soledad Mountain," on the north side of the creek, on a small ridge formed by the creek and sea cliff, elevation 22 m, La Jolla quadrangle, San Diego, California.

5089. 91 m (300 ft.) north of the Scripps Institution pier, in the conglomerate above the mudstone. In the sea cliff, elevation 3 m, La Jolla quadrangle, San Diego County, California.

7000. [Exact location not known]. Las Lajas Canyon, in first canyon on north side of road, .4 km east of point where boundary line of Century Oil property crosses road, Santa Susana quadrangle, Ventura County, California.

7004. About 91 m east of locality 7003 in next small canyon that enters Lajas Canyon from the east just south of the most northerly extension of the 717-m (1500-ft.)

contour, Santa Susana quadrangle, Ventura County, California. Locality is equivalent to CSUN loc. 374.

7009. At elevation of 378 m in a small gully, in sandy shale about 100 m north of UCMP loc. 3759 [= 2134 m south of BM 961 at Santa Susana well, flank of 717-m (1500-ft.) hill] in sandy shale, 378 m elevation, Santa Susana quadrangle, Ventura County, California. Collected by R.B. Stewart.

A-836. About 3 km west of town of Remote, in bed of Middle Fork of Coquille River opposite Roseburg-Coos Bay Highway 42, White Rock quadrangle, Coos County, southwestern Oregon.

A-838. West of town of Remote, in bed of Middle Fork of Coquille River opposite Roseburg-Coos Bay Highway 42, White Rock quadrangle, Coos County, southwestern Oregon.

A-993. Second gully past Marrland Canyon (now known as Las Lajas Canyon) at second small falls up gully approximately 183 m, Santa Susana quadrangle, Ventura County, California.

A-994. About 69 to 91 m down the canyon from UCMP loc. A-993 on west side of canyon about 18 m from streambed, Santa Susana quadrangle, Ventura County, California.

UW LOCALITY

329. On north bank of the Cowlitz River at bend 1.5 to 2.5 km east of Vader, section 28, T 1 N, R 2 W, Castle Rock quadrangle (15-minute), 1953, Lewis County, Washington.

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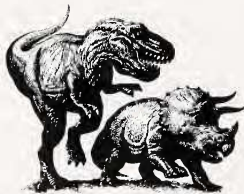
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